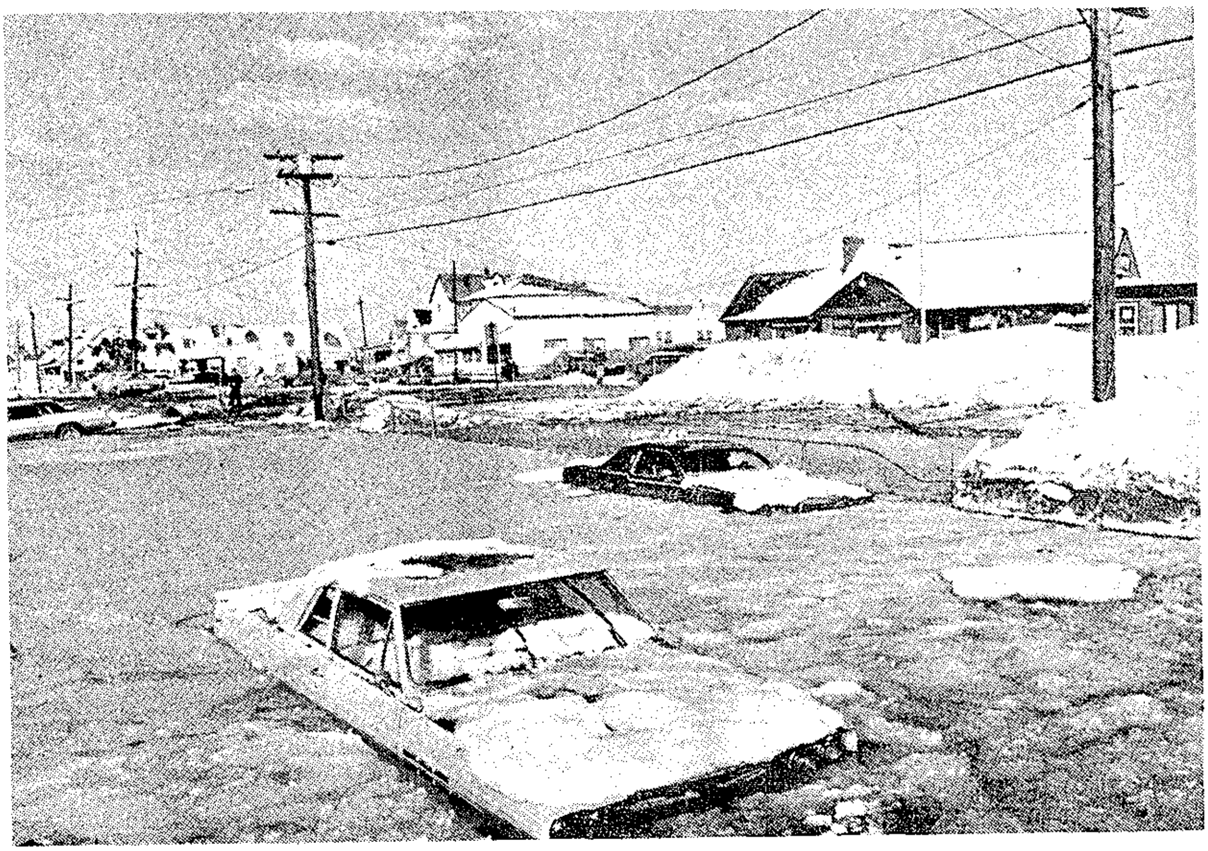
Water Resources Investigation

Interim **Report**

Support Documentation - Volume II

Roughans Point Revere, Massachusetts Coastal Flood Protection Study



US Army Corps of Engineers

New England Division

DECEMBER 1982

(REV. OCT. 1983)

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF

ROUGHANS POINT
REVERE, MASSACHUSETTS

COASTAL FLOOD PROTECTION STUDY

REVERE COASTAL
FLOOD PROTECTION STUDY

ROUGHANS POINT

INDEX OF VOLUMES

VOLUME I

VOLUME II

ACKNOWLEDGEMENTS

The New England Division (NED), U.S. Army Corps of Engineers prepared this report under the overall direction of Colonel Carl B. Sciple, Division Engineer and Joseph L. Ignazio, Chief of the Planning Division. The Basin Management Branch (BMB) of the Planning Division has overall responsiblity for the study under the supervision of its Chief, Donald W. Martin. Study management is provided by the Comprehensive River Basin Section (CRBS) headed by Arthur F. Doyle of BMB.

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Thanks are extended to the city of Revere's Department of Planning and Community Development. Frank Stringi and Paul Rupp helped significantly with the study's public involvement program.

Additional thanks are in order to the Workshop Committee, especially Ellen Haas whose cooperation and dedication were invaluable.

Gerald Salemme of Congressman Markey's Office should also be recognized for his coordination efforts which contributed to the progress of the study.

The Metropolitan District Commission (MDC), the Division of Waterways, the Office of Coastal Zone Management (CZM), and the Massachusetts Environmental Policy Unit (MEPA) of the Commonwealth of Massachusetts are acknowledged for their continuing cooperation in NED activities.

EXECUTIVE SUMMARY

Revere, Massachusetts is a coastal commmunity located immediately north of Boston and Winthrop. Flooding, due to storm tides and wave overtopping, is a constant concern. An initial study completed in 1980 found that coastal flood protection appeared to be economically feasible.

The Revere area is divided into three separate zones: Roughans Point, Point of Pines, and Revere Beach Backshore areas. This report is an interim response to the flood protection needs of Roughans Point - the neighborhood suffering the most intense and frequent damages. Feasibility studies of flood damage reduction opportunities for the other zones in Revere will be submitted separately.

Average annual flood losses for Roughans Point are over $1.0 million. A recurrence of the "Blizzard of February 1978", the flood of record, would result in nearly $11.1 million in damages. Over 300 structures, of which 291 are homes, would be inundated with an average of four feet and up to 8 feet of water!

The Corps evaluated many alternative protective measures to reduce flood losses at Roughans Point. Input from the public involvement program, along with close coordination with the city of Revere, helped establish the necessary criteria leading to recommendation of a particular plan. The public desires a comprehensive solution offering a high degree of protection.

The recommended plan includes 4,080 feet of armor stone revetments sloping seaward along the Roughans Point shore to dissipate incoming waves. Interior drainage provisions include the existing pumping station and a new emergency gravity drain through the line of protection. An earth berm, one foot high and 200 feet long would be built on an existing road median strip to prevent backwater flooding. An improved flood forecast, warning and evacuation plan would also be developed for the city. This plan provides protection to over 300 structures in the flood plain. The project would prevent 93 percent of the potential average annual damages at an estimated first cost of $8.7 million. The BCR is 1.6 to 1. This plan reasonably maximizes net economic benefits and would not cause significant adverse impacts on the environment. The plan is supported and sponsored by the city of Revere.

The costs, as presented, are considered conservative. The proportion allotted for contingencies and post-feasibility engineering is cautious. This proportion will be refined as project design is finalized.

ROUGHANS POINT
REVERE, MASSACHUSETTS
COASTAL FLOOD PROTECTION STUDY

VOLUME II

SUPPORT DOCUMENTATION

TABLE OF CONTENTS

	Page No.
APPENDIX E - ECONOMICS	
Methodology	E-1
First Costs	E-1
Annual Costs	E-1
Damage Survey	E-2
Recurring Flood Losses	E-19
Annual Flood Losses	E-21
Flood Inundation Reduction	E-21
Affluence Benefits	E-22
Emergency Costs	E-23
Benefits from the Reduction in Insurance Overhead	E-26
Other Benefits	E-26
Economic Justification	E-27
Development of NED Plan and Net Benefit Maximization	E-27
Update of Stage 2 Plans	E-27
Maximization of Net Benefits	E-28

STUDY RESOLUTION

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on the Land and Water Resources of the New England-New York Region, transmitted to the President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document Numbered 14, Eighty-fifth Congress, with a view to determining the feasibility of providing water resource improvements for flood control, navigation and related purposes in Southeastern New England for those watersheds, streams and estuaries which drain into the Atlantic Ocean and its bays and sounds in the reach of the coastline of Massachusetts, Rhode Island and Connecticut southerly of, and not including, the Merrimac River in Massachusetts, to, and including, the Merrimac River in Massachusetts, to, and including, the Pawcatuck River in Rhode Island and Connecticut, with due consideration for enhancing the economic grwth and quality of the environment.

ADOPTED: September 12, 1969
91st Congress, 1st Session

COASTAL FLOOD PROTECTION STUDY
ROUGHANS POINT STAGE III INVESTIGATION
REVERE, MASSACHUSETTS

APPENDIX A
HYDROLOGY AND HYDRAULICS

PREPARED BY

THE
HYDRAULICS AND WATER QUALITY, AND HYDROLOGIC ENGINEERING SECTIONS
WATER CONTROL BRANCH

AND

THE
COASTAL ENGINEERING AND SURVEY SECTION
DESIGN BRANCH

ENGINEERING DIVISION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254

COASTAL FLOOD PROTECTION STUDY
ROUGHANS POINT STAGE III INVESTIGATION
REVERE, MASSACHUSETTS

APPENDIX A
HYDROLOGY AND HYDRAULICS

TABLE OF CONTENTS

COASTAL FLOOD PROTECTION STUDY
ROUGHANS POINT STAGE III INVESTIGATION
REVERE, MASSACHUSETTS

APPENDIX A
HYDROLOGY AND HYDRAULICS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

COASTAL FLOOD PROTECTION STUDY
ROUGHANS POINT STAGE III INVESTIGATION
REVERE, MASSACHUSETTS

APPENDIX A
HYDROLOGY AND HYDRAULICS

LIST OF FIGURES

LIST OF PLATES

COASTAL FLOOD PROTECTION STUDY
ROUGHANS POINT STAGE III INVESTIGATION
REVERE, MASSACHUSETTS

APPENDIX A
HYDROLOGY AND HYDRAULICS

INTRODUCTION

A-1. GENERAL

Overtopping of existing walls and dikes by wind-generated waves is the principal agent of coastal flooding in the Roughans Point area of Revere, Massachusetts. Rainfall runoff also contributes to interior flooding. The amount of wave overtopping is significantly effected by the wave characteristics, local winds, geometry of protective works and ocean level. Substantial variations in water level can be produced by astronomical tides and by storm surges caused by the combination of high onshore winds and low atmospheric pressure. The coincidence of high water level, large waves, and strong onshore winds causes a threat of very serious flooding due to wave overtopping. This appendix presents hydrologic and hydraulic information and analyses pertinent to flood protection planning for the Roughans Point area of Revere, Massachusetts. Included are sections on: (a) general climatology of the area, (b) tidal hydrologic analysis of ocean level variations, (c) hydraulic analysis of wave runup and overtopping and development of the Standard Project Northeaster tide level, and (c) hydrologic analysis of interior flooding and interior drainage design. Cursory hydrologic and hydraulic analysis were performed during Stage II scoping studies for alternative projects with various levels of protection. Stage III reporting deals more specifically with selected alternatives and proposed level of protection. The intention of this appendix is to supplement the main report and provide hydrology and hydraulic information necessary for the formulation of flood control measures at Roughans Point.

CLIMATOLOGY

A-2. GENERAL.

Revere, Massachusetts, located at 42 degrees north latitude, has a cool, semi-humid, and most variable climate, typical of New England. Its climate is somewhat less harsh than in the higher inland areas of New England due to the moderating effect of the adjacent ocean waters. Its location on the easterly facing coast of New England exposes the Roughans Point area of Revere to coastal storms that move northeasterly up the Atlantic Coast with accompanying intense rainfall, winds and flood producing storm tides and waves.

A-3. TEMPERATURE.

The mean annual temperature at Revere is 51° Fahrenheit. Mean monthly temperature varies from a high of 72° in July to 29° Fahrenheit in January and February. Extremes in temperature vary from summertime highs in the nineties to wintertime lows in the minus teens. Mean, maximum and minimum monthly temperatures as recorded over a 109 year period at neighboring Boston are listed in Table A-1.

TABLE A-1

MONTHLY TEMPERATURE
BOSTON, MASSACHUSETTS
Elevation 15 Feet NGVD
109 Years of Record
(Degrees Fahrenheit)

Month	Mean	Maximum	Minimum
January	29.0	72	-13
February	29.3	68	-11
March	37.7	86	-8
April	47.4	89	11
May	57.9	97	31
June	67.3	100	42
July	72.5	104	46
August	71.6	101	47
September	64.4	102	34
October	54.9	90	25
November	44.5	83	-2
December	32.9	69	-14
Annual	50.8	104	-14

A-4. PRECIPITATION.

The mean annual precipitation at Revere is 42 inches based on 110 continuous years of record at neighboring Boston. Precipitation is distributed quite uniformly throughout the year, averaging about 3.5 inches per month. Short duration intense rainfall often results with fast moving frontal systems, thunderstorms, and coastal storms. Also much of the winter precipitation occurs as snowfall. Mean, maximum and minimum monthly precipitation recorded at Boston, Massachusetts is listed in Table A-2.

TABLE A-2

MONTHLY PRECIPITATION
BOSTON, MASSACHUSETTS
Elevation 15 Feet NGVD
110 Years of Record
(Inches)

Month	Mean	Maximum	Minimum
January	3.67	10.55	0.35
February	3.35	9.98	0.45
March	3.84	11.75	Trace
April	3.55	10.83	0.20
May	3.24	13.38	0.25
June	3.13	9.13	0.27
July	3.12	12.38	0.52
August	3.64	17.09	0.37
September	3.23	11.95	0.21
October	3.27	8.84	0.06
November	3.80	11.63	0.59
December	3.70	9.74	0.26
Annual	41.54	67.72	23.71

A-5. SNOWFALL

The average annual snowfall at Revere is 43 inches. Mean monthly and annual snowfall recorded at Boston is listed in Table A-3. Data on seasonal snowpack is not available for Revere. However, snow surveys by the Corps of Engineers in the Blackstone River basin, about 20 miles south and 15 miles inland from Boston, indicate maximum water equivalent occurs about the 1st of March, ranging from near zero to about 6 inches,with an average of about 2.7 inches.

TABLE A-3

MEAN MONTHLY SNOWFALL
BOSTON, MASSACHUSETTS
Elevation 15 Feet NGVD
110 Years of Record
(Average Depth in Inches)

Month	Snowfall
January	11.9
February	12.5
March	7.7
April	1.6
May	Trace
June	0
July	0
August	0
September	0
October	Trace
November	1.4
December	8.0
Annual	43.1

TIDAL HYDROLOGY

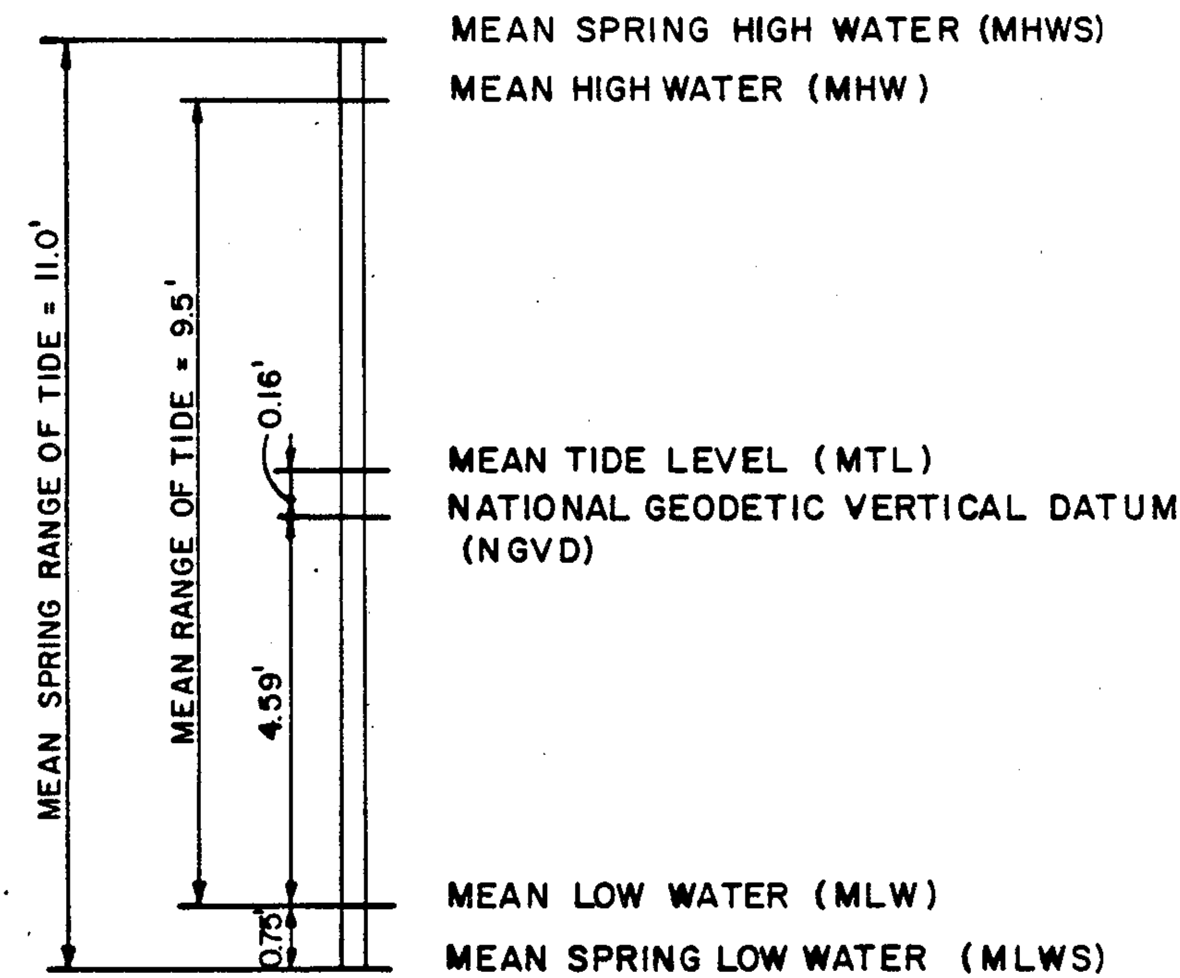
A-6. ASTRONOMICAL TIDES

At Revere, tides are semidurnal, with two high and two low waters occurring during each lunar day (approximately 24 hours 50 minutes). The resulting tide range is constantly varying in response to the relative positions of the earth, moon, and sun; the moon having the primary tide producing effect. Maximum tide ranges occur when the orbital cycles of these bodies are in phase. A complete sequence of tide ranges is approximately repeated over an interval of 19 years, which is known as a tidal epoch. At the National Ocean Survey (NOS) tide gage in Boston, Massachusetts (the one nearest to Revere), the mean range of tide and the mean spring range of tide are 9.5 feet and 11.0 feet, respectively (see Figure A-1). However, the maximum and minimum probable astronomic tide ranges at Boston have been estimated at about 14.7 and 5.0 feet, respectively, in studies by the Corps Coastal Engineering Research Center (CERC). The variability of astronomical tide ranges is a very significant factor in tidal flooding potential at Revere. This is explained further in Section A-9.

FIGURE A-1

TIDAL DATUM PLANES
BOSTON, MASSACHUSETTS
NATIONAL OCEAN SURVEY TIDE GAGE

(BASED UPON 1941-59 NOS TIDAL EPOCH)



NEW ENGLAND DIVISION
U.S. ARMY, CORPS OF ENGINEERS
WALTHAM, MASS. JUNE 1981

Because of the continual variation in water level due to the tides, several reference planes, called tidal datums, have been defined to serve as a reference zero for measuring elevations of both land and water. Tidal datum information for Boston is presented on Figure A-1 and Table A-4. These data were compiled using currently available NOS tidal benchmark data for Boston along with the CERC report entitled, "Tides and Tidal Datums in the United States," SR No. 7, 1981. The epoch for which the National Ocean Survey has published tidal datum information for Boston is 1941-59. A phenomenon that has been observed through tide gaging and tidal benchmark measurements is that sea level is apparently rising with respect to the land along most of the U.S. coast. At the Boston, National Ocean Survey tide gage, the rise has been observed to be slightly less than 0.1 foot per decade. Sea level determination is generally revised at intervals of about 25 years to account for the changing sea level phenomenon. The National Ocean Survey is presently engaged in the process of reducing data from the 1960-1978 tidal datum epoch to make such a revision.

TABLE A-4

BOSTON TIDAL DATUM PLANES
NATIONAL OCEAN SURVEY TIDE GAGE
(BASED UPON 1941-59 NOS TIDAL EPOCH)

	Tide Level (Ft., NGVD)
Maximum Probable Astronomic High Water	7.4
Mean Spring High Water (MHWS)	5.7
Mean High Water (MHW)	4.9
Minimum Probable Astronomic High Water	2.6
Mean Tide Level (MTL)	0.2
National Geodetical Vertical Datum (NGVD)	0.0
Maximum Probable Astronomic Low Water	-2.5
Mean Low Water (MLW)	-4.6
Mean Spring Low Water (MLWS)	-5.3
Minimum Probable Astronomic Low Water	-7.2

A-7. STORM TYPES

Two distinct types of storms, distinguished primarily by their place of origin as being extratropical and tropical cyclones, influence coastal processes in New England. These storms can produce above normal water levels and must be recognized in studying New England coastal problems.

a. Extratropical Cyclones - These are the most frequently occurring variety of cyclones in New England. Low pressure centers frequently form or intensify along the boundary between a cold dry continental air mass and a warm moist marine air mass just off the coast of Georgia or the Carolinas and move northeastward more or less parallel to the coast. These storms derive their energy from the temperature contrast between cold and warm air masses. The organized circulation pattern associated with this type of storm may extend for 1,000 to 1,500 miles from storm center. The wind field in an extratropical cyclone is generally asymmetric with the highest winds in the northeastern quadrant. Since the storms center generally passes parallel and to the southeast of the New England coastline, highest onshore wind speeds are generally from the northeast. For this reason these storms are called "northeasters" or "nor'easters" by New Englanders. As the storm passes, local wind directions may vary from southeast to slightly west of north. Coastline exposed to these winds can experience high waves and extreme storm surge. Such storms are the principal tidal flood producing events at Revere. The prime season for northeasters in New England is November through April.

b. Tropical Cyclones - These storms form in a warm moist air mass over the Caribbean and the waters adjacent to the West Coast of Africa. The air mass is nearly uniform in all directions from the storm center. The energy for the storm is provided by the latent heat of condensation. When the maximum wind speed in a tropical cyclone exceeds 75 mph, it is labeled a hurricane. Wind velocity at any position can be estimated based upon the distance from the storm center and the forward speed of the storm. The organized wind field may not extend more than 300 to 500 miles from the storm center. Recent hurricanes affecting New England generally have crossed Long Island Sound and proceeded landward in a generally northerly direction. However, hurricane tracks can be erratic. The storms lose much of their strength after landfall. For this reason the southern coast of New England experiences the greatest surge and wave action from the strong southerly to easterly flowing hurricane winds. However, on very rare occasions, reaches of coastline in northern New England may experience some storm surge and wave action from the weakened storm. Hurricanes are not a principle cause of tidal flooding at Revere. The hurricane season in New England generally extends from August through October.

A-8. WINDS

An estimate of wind speed is one of the essential ingredients in determining design wave parameters. The most accurate estimate of winds at sea, which can generate waves and propel them landward, is obtained by utilizing isobars of barometric pressure recorded during a given storm. Wind speed and direction data recorded at land based coastal meteorological stations may not be totally indicative of wind velocities at the sea-air interface far out at sea where the waves are generated.

When estimating wave overtopping of coastal structures,it is necessary to utilize local wind conditions. These local winds help determine how much of the runup from breaking waves is blown over the structures. Examination of wind conditions occurring during past storms is useful when estimating the severity of wave overtopping conditions. Table A-5 presents National Weather Service (NWS) wind observations recorded at Logan Airport in Boston during notable tidal floods. (Owing to Logan Airport being in immediate proximity, wind conditions there are considered to be the same as at Revere.) From these data it can be seen that the strongest winds recorded during flood events generally originated from directions between northeast and east. The greatest fastest-mile (approximately equal to one-minute average speed) listed, 61 mph from the northeast, was recorded on 6 February 1978 during the great "Blizzard of '78." By comparing Table A-5 with Table A-8 it can be seen that the stillwater tide levels recorded during these storm events ranged between 10.3 and 8.3 feet NGVD, with recurrence intervals of between 91 and 2 years, respectively. However, extremely severe onshore winds have occured during storm events which produced significantly lower observed maximum stillwater tide levels in the study area.

TABLE A-5

BOSTON - LOGAN INTERNATIONAL AIRPORT
NATIONAL WEATHER SERVICE
WIND OBSERVATIONS RECORDED
DURING NOTABLE TIDAL FLOODS

Date	Resultant Direction	Resultant Speed (mph)	Average Speed (mph)	Fastest-Mile Speed (mph)	Fastest-Mile Direction
6 Feb 1978	ENE	28.4	29.3	61	NE
29 Dec 1959	NE*	-	20.7	34	E
25 Jan 1979	ENE	23.2	24.2	45	E
19 Feb 1972	NE	21.1	24.2	47	NE
25 May 1967	NE	34.3	34.7	50	NE
21 Apr 1940	-	-	13.3	43 **	NE
20 Jan 1961	NNW*	-	26.7	41	NNE
30 Nov 1944	-	-	13.4	48 **	NE
9 Jan 1978	SSW	22.8	28.8	43	SW
16 Mar 1976	ENE	15.4	20.4	35	NE
16 Mar 1956	ENE*	-	28.1	54	NE
6 Apr 1958	WSW*	-	13.8	32	SSE
26 Feb 1979	NE	19.1	19.6	30	NE
2 Dec 1974	ENE	15.7	20.7	38	E
7 Mar 1962	NE*	-	31.6	42	ENE
4 Apr 1973	E	13.0	13.5	31	E
22 Dec 1972	N	13.3	13.5	21	N

*Resultant speed and direction not available for the period prior to 1964; direction shown is prevailing wind direction.
**Fastest-mile not available; value shown in five-minute average speed.

NOTE: Listing is in order of decreasing observed stillwater tide level to provide uniformity with Table A-8.

Since the astronomic tide range at Revere is so variable, as explained in Section A-6, many severe coastal storms occur during periods of relatively low astronomic tides. Thus, even though a storm may produce exceptionally high onshore winds and a tidal surge, the resulting tide level may be less than that occurring during a time of high astronomic tide and no meterological influence. Table A-6 presents wind data recorded at Logan Airport during storms which produced annual maximum surge values of three feet or more. Comparison which Table A-7 shows that the recurrence intervals of the maximum observed tide levels recorded on days of maximum annual storm surge were generally less than one year, with only a few storms producing significant tidal flood levels. Some of the most severe onshore winds and storm surge are shown to have produced minor tidal flooding, owing to their conincidence with low astronmic tides. A good example of this is the 29 November 1945 event which produced the maximum storm surge of record at Boston; extremely high onshore winds occurred during low astronomic tide and resulted in only a minor tidal flood level (7.6 feet NGVD).

Conversely, rather significant tidal flood levels can result from the conincidence of relatively high astronomic tides and only minor meteorological events. Astronomic high tide level in Boston alone can reach 7.4 feet NGVD (see Table A-4). With such a condition, a coincident storm surge of only two to three feet could produce major tidal flood levels. The February 7, 1978 storm tide at Boston reached 10.3 feet NGVD, the greatest of record, but was produced by a combination of astronomic tide of 6.9 feet NGVD and surge of 3.4 feet, the latter being of only moderate magnitude (see Table A-7).

Hourly observations of one-minute average wind speed, recorded by the NWS at Boston's Logan Airport from 1945 through 1964, were analyzed to determine wind speed persistence on a directional basis. The resulting wind speed persistence data, shown on Plates A-6a through A-6g, for directions north-northeast through south-southeast, indicate the number of consecutive hourly wind speed observations that occurred at or above a given speed from a particular direction. Data on Plate A-6b disclose one occurrence of winds in excess of 50 mph for five consecutive hours from the northeast. Eight consecutive hourly values greater than 50 mph from the east-northeast are shown on Plate A-6c, while four such values greater than 50 mph from the east-southeast, are shown on Plate A-6e. Winds averaging 71 mph from the southeast are shown on Plate A-6f to have occurred for two consecutive hours. All these data indicate that extremely high onshore winds can occur for extended periods of time in the study area.

Additionally, Memorandum HUR 8-5 entitled, "Criteria for a Standard Project Northeaster for New England North of Cape Cod" indicates that during maximum storm intensity a Standard Project Northeaster could produce winds approaching 60 knots (69 mph) from the northeast at the project site. Therefore, for design analysis it was assumed that local winds would be about 60 mph from the NE during the period of wave overtopping.

TABLE A-6

BOSTON LOGAN INTERNATIONAL AIRPORT
NATIONAL WEATHER SERVICE
WIND OBSERVATIONS RECORDED
DURING ANNUAL MAXIMUM SURGE
PRODUCING STORMS
(1922-1979)

Date	Fatest-Mile Speed (mph)	Fatest-Mile Direction	Average Speed (mph)	Prevailing Direction
29 Nov 1945	63 *	NE	40.5	-
13 Apr 1961	42	ENE	25.0	NE
6 Feb 1978	61	NE	29.3	ENE
14 Feb 1940	51 *	NE	12.7	-
17 Nov 1935	54 *	NE	14.9	-
3 Mar 1947	50 *	E	13.4	-
4 Mar 1960	45	NE	28.0	N
19 Feb 1972	47	NE	24.2	NE
30 Jan 1966	43	S	22.3	SSE
31 Aug 1954	86	SE	31.8	ENE
16 Feb 1958	45	E	28.0	E
12 Nov 1968	54	NE	23.9	E
25 Jan 1979	45	E	24.2	ENE
16 Mar 1956	54	NE	28.1	ENE
22 Mar 1977	60	NE	19.3	E
15 Nov 1962	37	NW	28.5	NW
11 Mar 1924	-	-	-	-
30 Jan 1939	43 *	NE	12.7	-
17 Feb 1952	50	NE	29.8	NE
7 Mar 1923	-	-	-	-
20 Feb 1927	-	-	-	-
19 Jan 1936	40 *	NE	12.6	-
27 Dec 1969	26	E	17.3	WNW
25 Nov 1950	74	E	42.4	E
7 Nov 1953	67	NE	30.5	NE
12 Mar 1959	42	ESE	23.9	SE
16 Apr 1929	-	-	-	-
8 Mar 1931	-	-	-	-
14 Aug 1971	18	E	9.6	E
28 Jan 1973	23	NE	19.4	NE

*Fastest-mile not available; value shown is five-minute average speed.

NOTE: Listing in order of decreasing annual maximum storm surge to allow comparison with Table A-7.

A-9. STORM-TIDES AND TIDE STAGE-FREQUENCY

The total effect of astronomical tide combined with storm surge produced by wind, wave, and atmospheric pressure contributions is reflected in actual tide gage measurements. Since the astronomical tide is so variable at the study area, the time of occurrence of the storm surge greatly affects the magnitude of the resulting tidal flood level. Obviously, a storm surge of three feet occurring at a low astronomic tide would not produce as high a water level as would be produced if it occurred at a higher tide. It is important to note that the storm surge itself varies with time thus introducing another variable into the make-up of the total flood tide. The variation in observed tide, predicted tide, and surge at Boston during the "Blizzard of '78" is shown in Figure A-2. It is interesting to note that the maximum surge (4.7 ft.) occurred just before 10 PM on 6 February. However, the maximum observed tide occurred about 10:30 AM the following day when the surge had dropped by 1.3 ft. Had the maximum surge recorded during the storm occurred at 10:30 AM on 7 February the observed tide would have been 11.6 ft. NGVD, and would have resulted in even more catastrophic flooding at Revere. Annual maximum surge values of greater than or equal to 3.0 feet measured at the Boston, Massachusetts, National Ocean Survey (NOS) tide gage are shown in Table A-7. This table shows the importance of coincident astronomic tide in producing significant tidal flooding. (See the discussion in Section A-8 which deals with the wind observations recorded during these events.)

The NOS has systematically recorded tide heights at Boston, Massachusetts since 1922. The record prior to that time was developed utilizing staff gage measurements and historical accounts. Maximum observed stillwater tide heights (measurements taken in protected areas in which waves are dampened out) recorded up to 1980 are shown in Table A-8. Also shown are the tide heights with an adjustment applied to account for the effect of rising sea level (see section A-6). The greatest observed stillwater tide level recorded occurred during the "Great Blizzard of '78." No hurricanes or tropical storms have produced extreme tide heights at Boston, thus indicating that the principal threat of flooding in the study area is due to storms of the extratropical variety.

A tide stage-frequency relationship for Boston was previously developed utilizing a composite of a Pearson Type III distribution function, with expected probability adjustment, for analysis of historic and systemmatically observed annual maximum stillwater tide levels and a graphical solution of Weibull plot positions for partial duration series data. The resulting tide stage-frequency curve is shown on figure A-3.

NOS tide gage records and high water mark data gathered after major storms have been utilized in the development of profiles of tidal floods along the New England coast. Additionally, profiles of storm tides for selected recurrence intervals have been developed utilizing tide stage-frequency curves and high water mark information. A location map and profile for the reach of the New England coast bounding Revere are shown on figures A-4 and A-5, respectively.

" BLIZZARD OF '78 " 6-7 FEBRUARY 1978
BOSTON, MASS.

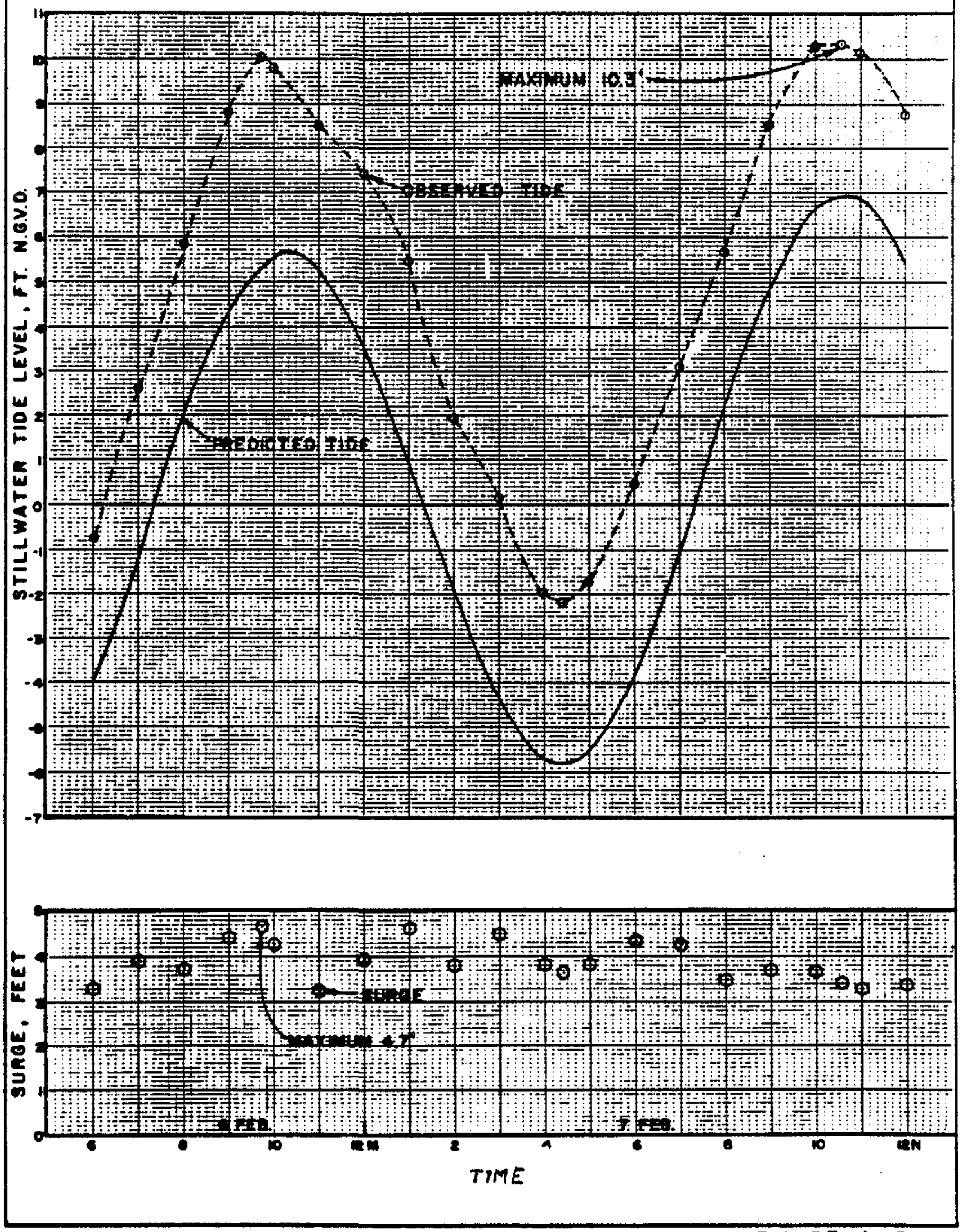


FIGURE A-2

TABLE A-7

ANNUAL MAXIMUM STORM SURGE
BOSTON, MASSACHUSETTS
(1922-1979)

Date	Annual Maximum Storm Surge (feet)	Maximum Observed Tide Level for the Day (ft., NGVD)	Recurrence* Interval (years)
30 Nov 1945	5.1	7.6	LT 1
13 Apr 1961	4.7	8.0	1
6 Feb 1978	4.7	10.0	50
14 Feb 1940	4.4	5.0	LT 1
17 Nov 1935	4.3	6.5	LT 1
3 Mar 1947	4.0	7.2	LT 1
4 Mar 1960	4.0	8.1	2
19 Feb 1972	4.0	9.1	10
30 Jan 1966	3.8	5.5	LT 1
31 Aug 1954	3.7	8.2	2
16 Feb 1958	3.7	7.9	1
12 Nov 1968	3.7	7.7	LT 1
25 Jan 1979	3.7	9.2	13
16 Mar 1956	3.6	5.6	LT 1
22 Mar 1977	3.6	5.3	LT 1
15 Nov 1962	3.5	7.9	1
11 Mar 1924	3.4	6.2	LT 1
31 Jan 1939	3.4	6.9	LT 1
18 Feb 1952	3.4	7.9	1
7 Mar 1923	3.3	6.9	LT 1
20 Feb 1927	3.3	6.9	LT 1
19 Jan 1936	3.3	5.9	LT 1
27 Dec 1969	3.3	6.7	LT 1
25 Nov 1950	3.2	6.4	LT 1
7 Nov 1953	3.2	7.4	LT 1
12 Mar 1959	3.1	6.5	LT 1
16 Apr 1929	3.0	6.6	LT 1
8 Mar 1931	3.0	6.5	LT 1
14 Aug 1971	3.0	5.4	LT 1
29 Jan 1973	3.0	6.1	LT 1

LT = Less Than
*Recurrence interval of observed tide elevations. Obtained from tide stage-frequency relationship, Figure A-3.

TABLE A-8

MAXIMUM STILLWATER TIDE HEIGHTS
BOSTON, MASSACHUSETTS

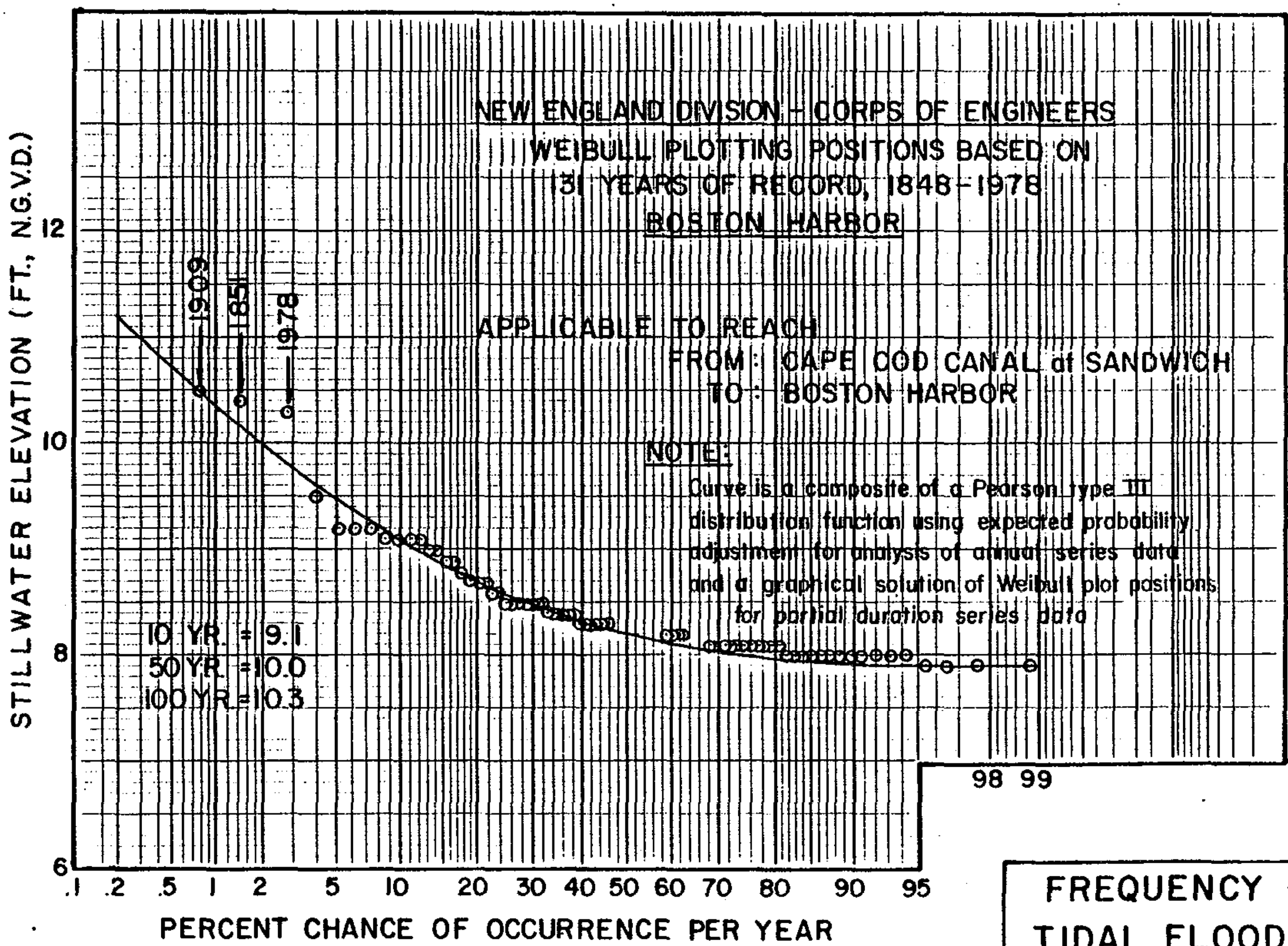
Date	Observed Elevation (Ft., NGVD)	Adjusted Elevation* (Ft., NGVD)	Recurrence*** Interval (Years)
7 Feb 1978	10.3	10.3	91
16 Apr 1851	10.1	10.4	63
26 Dec 1909	9.9	10.5	42
25 Jan 1979	9.3	9.3	14
29 Dec 1959	9.3	9.5	14
27 Dec 1839	9.2**	—	13
15 Dec 1839	9.2**	—	13
19 Feb 1972	9.1	9.1	11
24 Feb 1723	9.1**	—	11
26 Mar 1830	9.0**	—	9
26 May 1967	8.9	9.0	7
21 Apr 1940	8.9	9.3	7
29 Dec 1853	8.9	9.2	7
4 Dec 1786	8.9**	—	7
20 Jan 1961	8.8	8.9	6
30 Nov 1944	8.8	9.1	6
4 Mar 1931	8.8	9.2	6
3 Dec 1854	8.8	9.1	6
3 Nov 1861	8.7	9.1	5
9 Jan 1978	8.6	8.6	4
16 Mar 1976	8.6	8.6	4
17 Mar 1956	8.6	8.8	4
7 Apr 1958	8.5	8.7	4
15 Nov 1871	8.5	9.0	4
23 Nov 1858	8.5	8.9	4
26 Feb 1979	8.4	8.4	3
2 Dec 1974	8.4	8.4	3
7 Mar 1962	8.4	8.5	3
4 Apr 1973	8.3	8.3	2
22 Dec 1972	8.3	8.3	2
28 Jan 1933	8.3	8.7	2
31 Dec 1857	8.3	8.7	2

*Observed values after adjustment for changing mean sea level; adjustment made to 1975 mean sea level.

**Approximate value based upon historical account. Record not sufficient to document change of sea level for this time.

***Recurrence interval of observed tide elevations. Obtained from tide stage-frequency relationship, Figure A-3.

NOTE: Events occurring within about 30 days of a greater tide producing event are exluded from this list. Events recorded during years for which only partial records are available were also excluded.



FREQUENCY OF
TIDAL FLOODING
AT
BOSTON HARBOR

AUG. 1979

FIGURE A-3

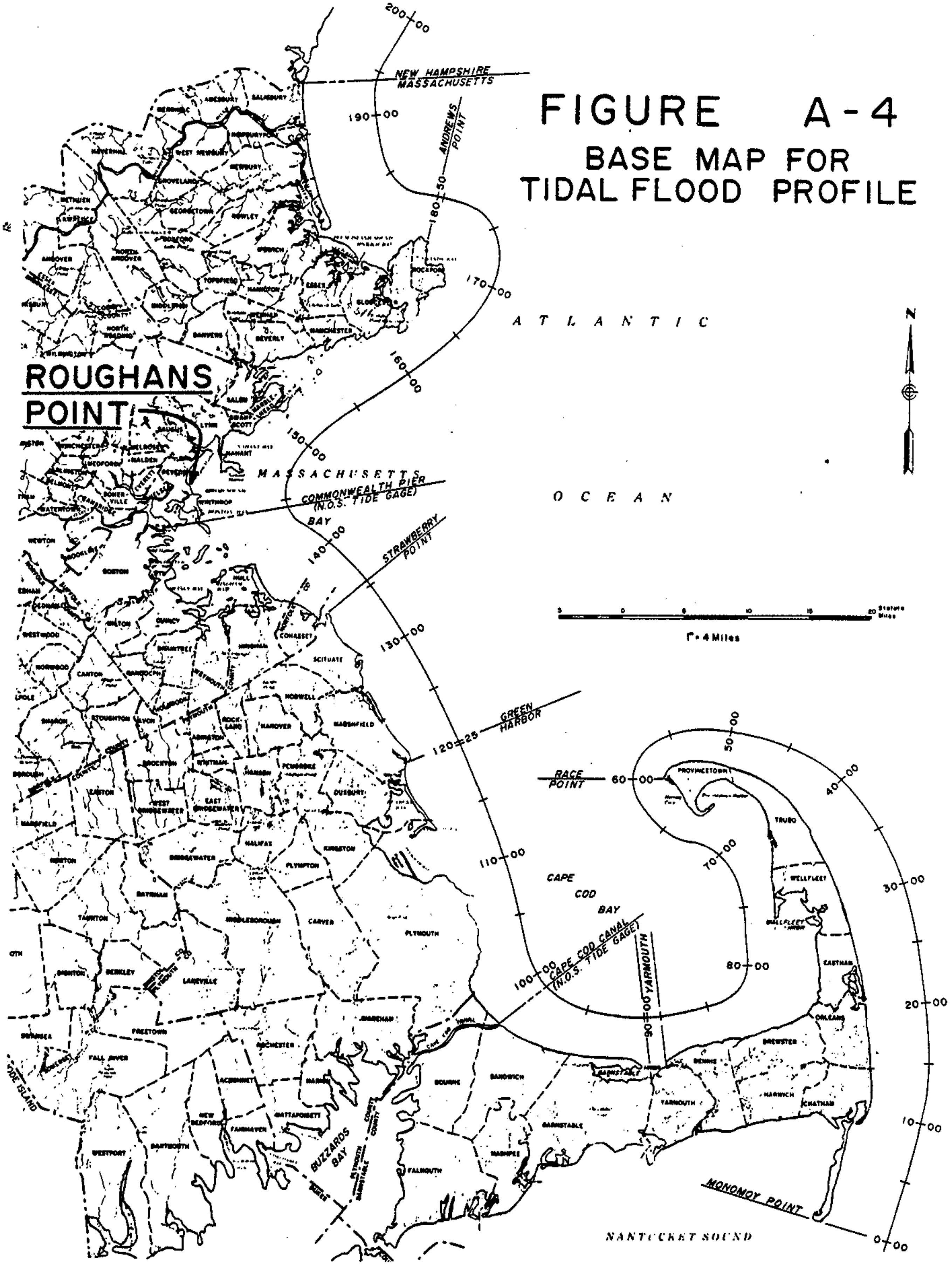
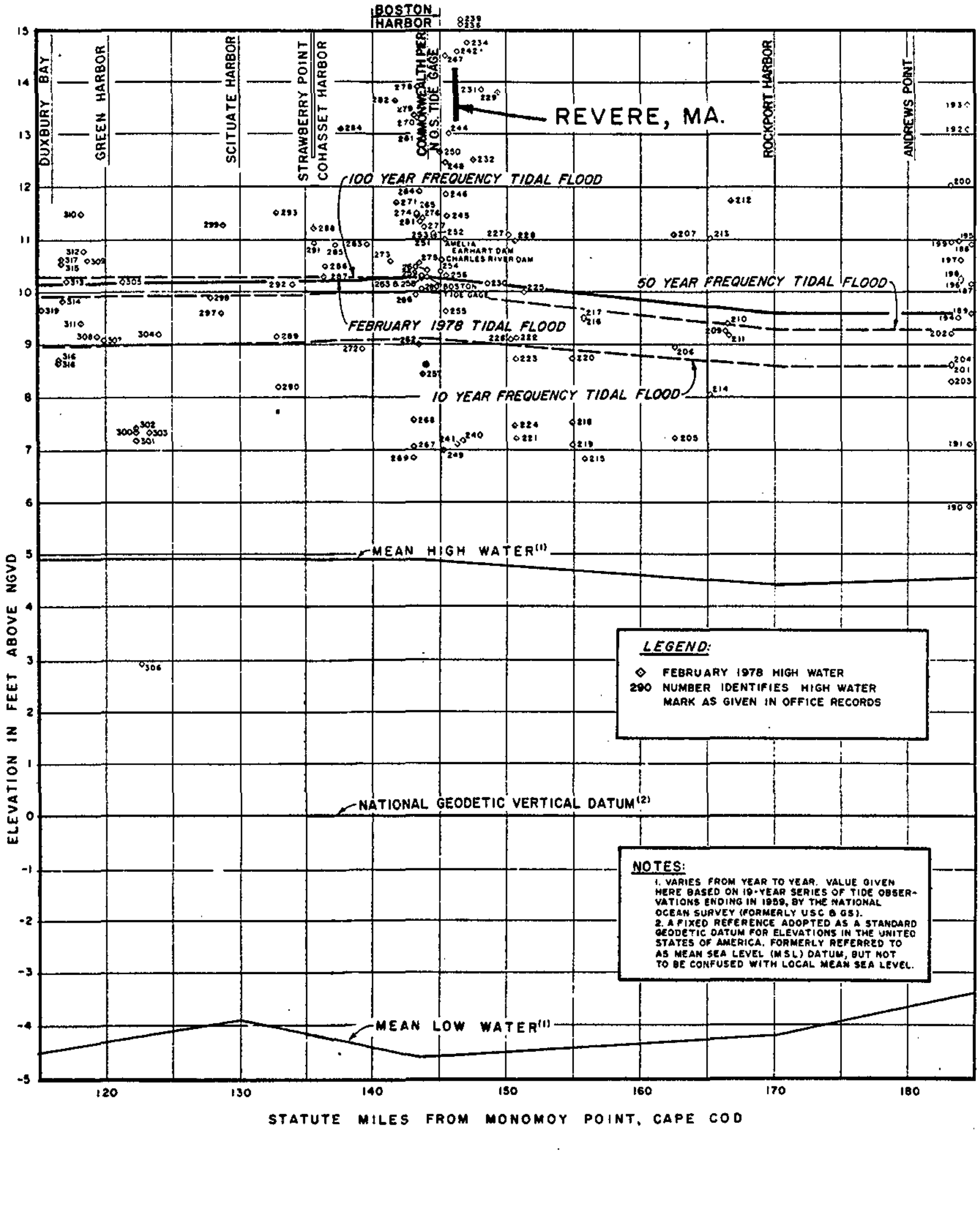


FIGURE A-4
BASE MAP FOR TIDAL FLOOD PROFILE

FIGURE A-5

TIDAL FLOOD PROFILE



A-10. STANDARD PROJECT NORTHEASTER (SPN) TIDE LEVEL

As this is the first study of coastal flood protection along the east coast of New England by the New England Division, Corps of Engineers, a SPN storm tide has not previously been developed. Although the meteorological criteria for such an event were published in U.S. Weather Bureau (USWB) Memorandum HUR 8-5, May 1963, the National Weather Service has advised that it would be necessary to revise the criteria to incorporate the characteristics of the great 6-7 February 1978 northeaster. The Wave Dynamics Division, U.S. Army Waterways Experiment Station (WES) has estimated that such revision would require about 6 months work.

Even after the meteorological criteria are established, mathematical hydraulic modeling and analysis will be required to actually arrive at the SPN tide level and wave heights. WES estimates about six months will be required to carry out this work.

The prospect of delaying the feasibility investigations while the SPN tide level was developed was considered unreasonable. With prior approval from the Office of the Chief of Engineers, NED proceeded through Stage III planning using an approximation of the SPN, determined as follows:

(1) The complete record (1922-present) of the NOS tide gage at Boston Harbor was analyzed to determine the maximum recorded storm surge (observed level minus predicted astronomic level). Previous analysis of the record up to 1960 only, performed by the USWB and shown in USWB Memorandum HUR 8-5, yielded a maximum surge of 5.1 feet. The Techniques Development Laboratory of the NWS, as a part of their studies of Boston tide data, updated this record to 1979 for NED and found that the 5.1-foot value remained as the maximum surge of record. By comparison, this surge value is only 0.4 feet higher than that experienced during the "Blizzard of '78."

(2) The maximum surge of record was then added to the maximum probable astronomic tide which was obtained from the CERC report entitled "Tides and Tidal Datums in the United States." As a comparison, the maximum probable astronomic tide is only 0.5 feet higher than the maximum astronomic tide which occurred during the 1978 storm event.

	Feet
Surge, Maximum Observed (30 Nov 1945)	5.1
Maximum Probable Astronomic Tide (NGVD)	7.4
Estimated SPN Stillwater Tide Level (NGVD)	12.5, say 13 feet

An SPN stillwater tide level of 13 feet was adopted for use in this planning investigation. Such an estimate appears reasonable when compared to the 6-7 February 1978 storm tide level of 10.3 feet NGVD, which is the greatest observed tide in Boston and which has a 1.0 percent chance of occurrence (100-year recurrence interval) annually. (See Figure A-3)

It is planned to carry out the more formal analysis for development of the SPN tide level at Revere such that it can be available for use in the post-authorization design period (GDM) in the event the project is approved for construction.

Concurrence in the above approach to the tidal hydrology aspect of the study and approval to proceed on that basis was received by letter from OCE in November 1980. (Ref. DAEN-CWE-H, 17 Nov. 1980, 1st Ind, Hydrologic Criteria-Revere, Massachusetts Coastal Flood Protection)

A-11. WAVE HEIGHT AND RUNUP

A design significant wave height of 9.0 feet was derived from the deep water wave forecasting curves contained in the Shore Protection Manual (SPM), 1977. This was based on the following coincident conditions:

a. Storm winds entering from the east-northeast, clockwise through the southeast, with an unlimited fetch; and

b. Wind speeds of 60 MPH from the same direction for a duration of 1-1/2 hours.

However, in no case can the wave experienced exceed 0.78 times the depth of water at the toe of the structure. Therefore, the maximum wave varies from 4 feet to 9 feet depending upon depth of water at the toe of the structure.

It is noted that the deepwater wave forecasting curves were revised after the design significant wave height had been determined and used in the project design. Comparison of the design significant wave heights determined by both old and revised curves showed they produced similar results, therefore it was decided to defer revising the project design to conform with the new wave guidance until the General Design Memorandum phase of the study. It is also noted that the new guidance itself is in the process of being revised, therefore, no design significant wave height changes will be made pending the outcome of these new guidance revisions.

Wave runup calculations were performed, using the SPM, for several stillwater tide levels along reaches A through F for existing conditions, as well as, for possible minimum vertical protection to elevation 14.0, 17.0 and 22.0 feet, NGVD. These levels were chosen based on existing top elevations of protection and also on the public acceptabiity factor. The proposed protection analized included a stone berm with a top width of

15.0 feet set at elevation 14.0 feet NGVD and having front slopes of both 1 vertical on 3 horizonal and 1 vertical on 4 horizontal, respectively, the idea being to break the incoming waves with a sloping face. (Existing and proposed methods of protection are described in detail in the main report.) Table A-9 shows the average top of runup levels computed for stillwater tide levels of 10.0, 11.0, and 13.0 feet NGVD.

TABLE A-9

WAVE RUNUP LEVELS
ROUGHANS POINT
REVERE, MASSACHUSETTS

Stillwater Tide Level (Ft., NGVD)	Average Top Elevation of Runup (Ft., NGVD)*		
	Existing Conditions	Front Slope: 1 on 3	Front Slope: 1 on 4
13.0	29.8	21.5	19.3
11.0	25.0	19.3	17.0
10.0	22.0	18.0	16.0

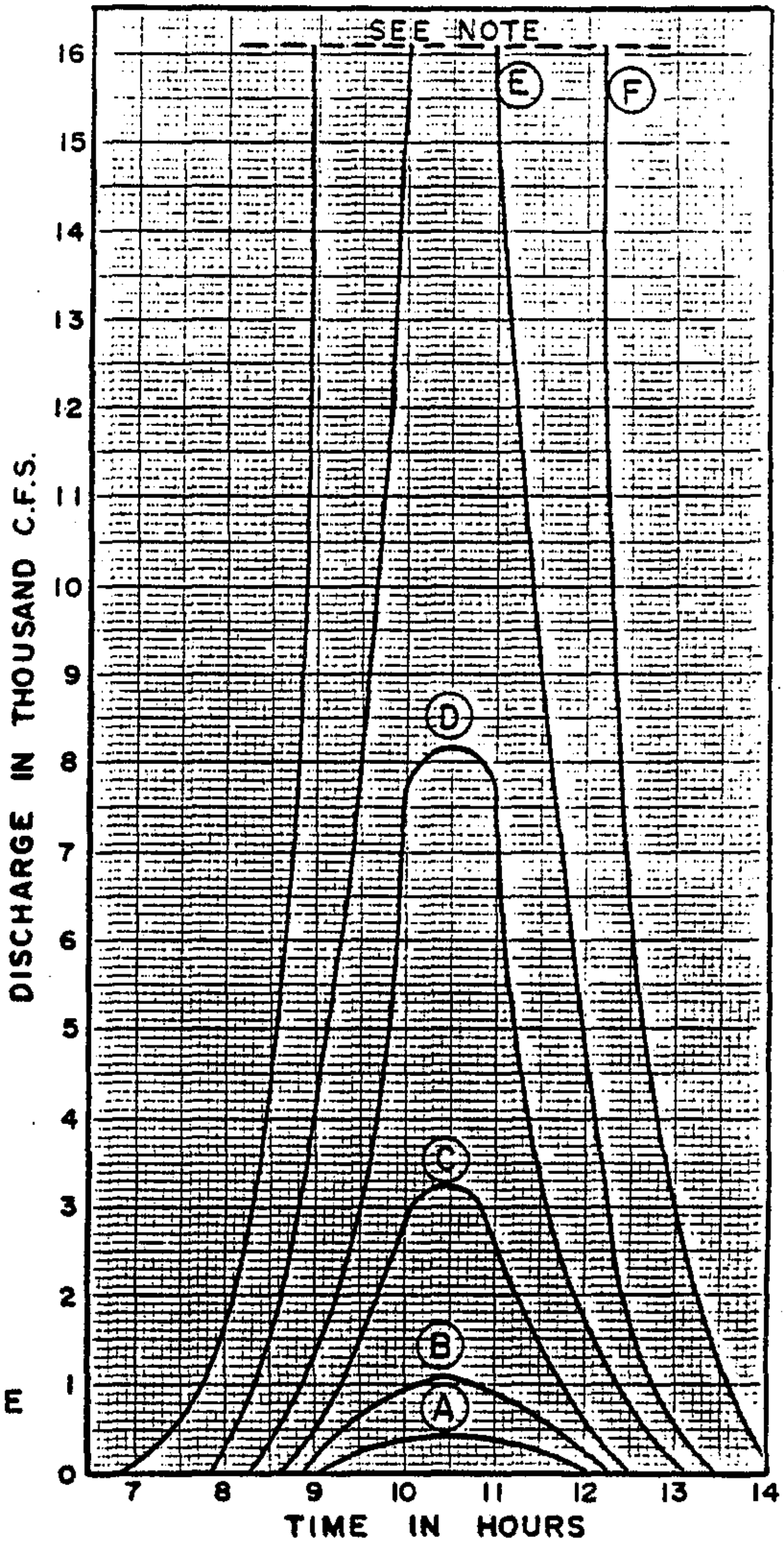
*Wave heights and top of runup vary along the different reaches, depending upon depth of water at the toe of the structure, and slope of the structure. Values presented here are average values for entire project length.

A-12. DESIGN WAVE OVERTOPPING

Estimates of wave overtopping have been computed for existing and proposed methods of protection for Roughans Point (descriptions of the protection types are provided in the main report). A local wind speed of about 60 mph from the northeast was assumed to be occurring during the period of wave overtopping.

Utilizing the methodology presented in Sections 7.221 and 7.222 of the 1977 edition of the Shore Protection Manual average rates of irregular wave overtopping were computed for various stillwater tide levels, thus, allowing for the development of rating curves of tide level versus overtopping rate. Tide stage hydrographs having selected maximum stillwater tide heights were then developed by appropriate adjustment of the tide hydrograph observed 7 February 1978 during the great northeaster of 6-7 February 1978. Combining this information, wave overtopping hydrographs for these tidal floods were then developed for use in interior flooding studies. Hydrographs developed for the existing condition and the selected plan are shown in Figures A-6 and A-7. Average rates of irregular wave overtopping at various tide levels for existing conditions, as well as for all the plans studied, are shown in Table A-10. Wave overtopping was not computed for a breakwater alternative because the high cost of this alternative has rendered it infeasible; nor was it computed for the 22.0 ft NGVD top of wall option, since the design wave runup would not exceed this height of wall.

HYDROGRAPH	MAXIMUM STILLWATER TIDE LEVEL (FT., N.G.V.D.)
A	7.0
B	8.0
C	9.0
D	10.0
E	11.0
F	13.0



ROUGHANS POINT

OVERTOPPING HYDROGRAPHS

EXISTING CONDITIONS

NOTE:

AT THIS POINT IN TIME THE STILLWATER TIDE LEVEL REACHES 10.9' N.G.V.D. AND PROTECTION AT SECTION D IS OVERTOPPED BY STILLWATER TIDE LEVEL.

FIGURE A-6

ROUGHANS POINT-SELECTED PLAN-OVERTOPPING HYDROGRAPHS
17' N.G.V.D. MINIMUM VERTICAL PROTECTION - 1 ON 3 SLOPE

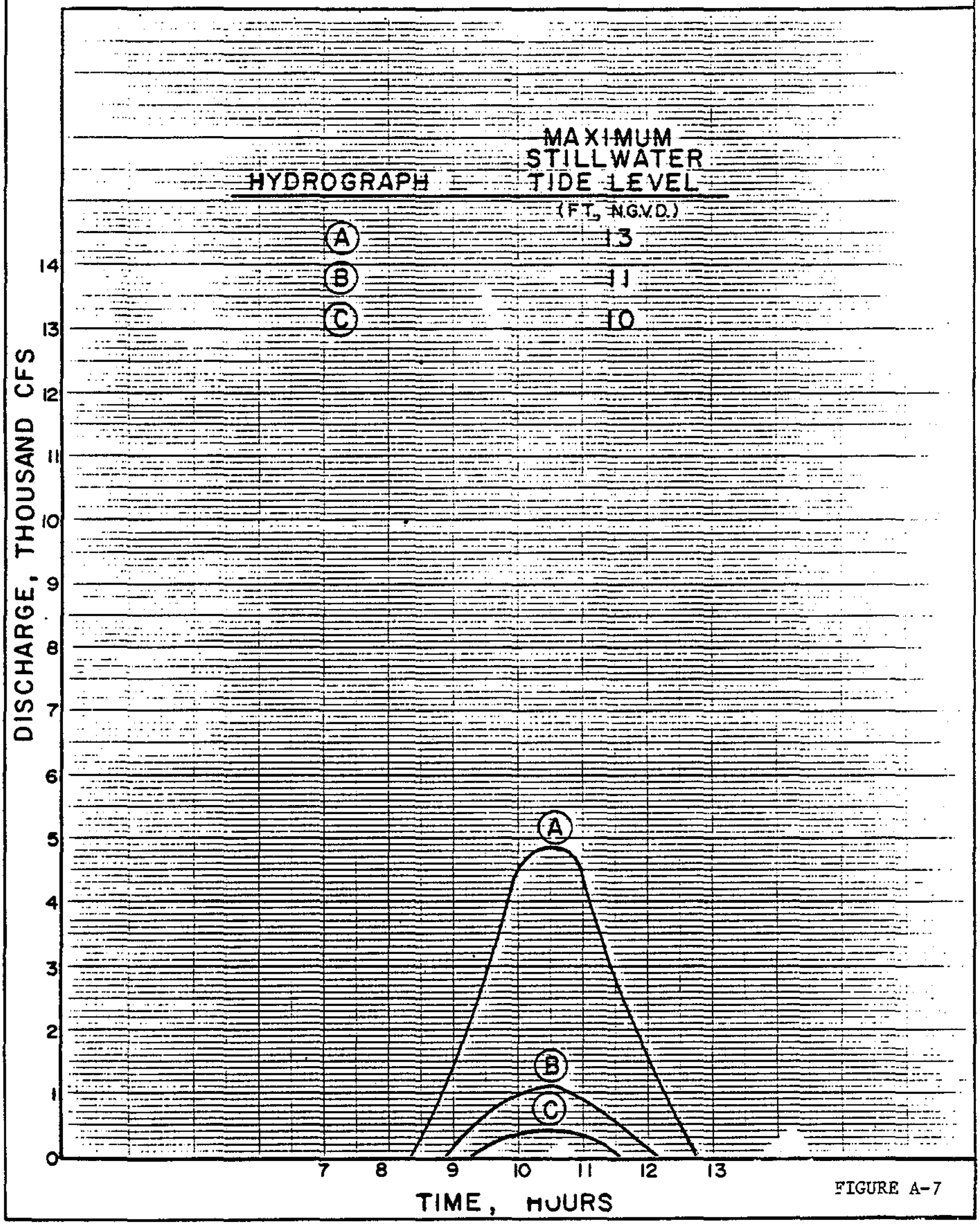


FIGURE A-7

TABLE A-10

WAVE OVERTOPPING RATES
ROUGHANS POINT
REVERE, MASSACHUSETTS

Stillwater Tide Level (Ft., NGVD)	Existing Conditions	Estimated Average Rate of Irregular Wave Overtopping in CFS: Minimum Top of Wall Level 17.5 feet, NGVD	Minimum Top of Wall Level: 17 feet, NGVD		Minimum Top of Wall Level: 14 feet, NGVD	
		Front Slope: 1 on 3	Front Slope: 1 on 3 (Selected Plan)	Front Slope: 1 on 4	Front Slope: 1 on 3	Front Slope: 1 on 4
13.0	*	4,250	4,850	2,100	18,000	12,700
12.0	*	2,300	2,600	600	8,500	4,900
11.0	*	980	1,100	**	3,950	1,550
10.0	8,250	350	400	**	1,800	550
9.0	3,300	**	**	**	700	50
8.0	1,100	**	**	**	150	**
7.0	450	**	**	**	**	**

*Section D, with a top elevation of 10.9 feet, NGVD, is overtopped by the stillwater tide level, therefore, wave overtopping rate was not computed.
**No substantial wave overtopping expected.

INTERIOR DRAINAGE

A-13. GENERAL.

Roughans Point is a low level area of about 55 acres, generally lying below elevation 10 feet NGVD. The interior area also receives drainage from about 30 acres of higher level Beachmont area to the south, making up a total interior drainage area of about 85 acres. A general plan of the interior area is shown on Plate A-1. Existing limited storm drainage facilities in the area, generally drain to the west (away from the ocean) discharging to Sales Creek, through a 42-inch diameter drain beneath Revere Beach Parkway. There is also an 18-inch flap-gated storm drain at the south end of Broad Sound Avenue that discharges through the existing line of protection to the ocean, tide level permitting. The capacity of the entire existing system is affected by ocean tide and during storm tides there is no gravity drainage from the area and interior runoff, plus any wave overtopping, ponds throughout the low level area. Temporary ponding depths of 1 to 2 feet, in low areas, are reportedly an annual event with depths as great as 6 to 8 feet on rare occasions, such as were experinced in February 1978. A pumping station was built in 1975 on Broad Sound Avenue for the purpose of pumping ponded waters from the street, through the line of protection to the ocean. This station has three pumps with a combined capacity of about 48 cfs (2 at 15 mgd, 1 at 1 mgd), however, station capacity is reportedly limited to about 39 cfs with present inlets and outlets. This station proved quite inadequate and ineffective during the February 1978 event due to the high rates of wave overtopping.

Sales Creek, which receives most of the normal interior drainage from Roughans Point, is a tidal estuary that originally drained west to the Chelsea River. However, the creek now drains west about 2,000 feet and then reverses direction draining southeast a distance of about 3,000 feet through Suffolk Downs racetrack discharging to the Belle Isle Inlet of Boston Harbor at Bennington Street. There is a tide gate on the stream at Bennington Street.

There is a history of flooding along Sales Creek due both to the poor hydraulic characteristics of the creek and its many culverts, and also to the absence of drainage during high tide. A plan of improvement for Sales Creek was developed by Andrew Christo Engineers for the Commonwealth of Massachusetts, Division of Waterways, in 1974. The plan includes channel and conduit improvements plus the construction of a pumping station and new tide gate at Bennington Street. The pumping station is presently being completed but major channel-conduit improvements have not been started. The completion of this plan and continued operation and maintenance of its extensive channel-conduit-station system, would result in an improved drainage outlet for the Roughans Point area provided improvements were made in its own local storm drainage system.

Sales Creek has a total watershed area of about 550 acres and the pumping station has a design capacity of 300 cfs, providing a pumping capacity equivalent to a runoff rate of over 1/2 inch per hour. This is considered a highly adequate capacity, considering the character of the watershed, its limited capacity storm drainage systems and the extremely limited gradient of the creek for moving the water to the station. The pumping station was sized by the designers based on the estimated maximum runoff rate resulting from a 4 percent chance (25-year) storm rainfall. (Ref: "Flood Control Study - Sales Creek, Revere", Andrew Christo Engineers, February 1974).

The designers of the Sales Creek improvements assumed that that part of the Roughans Point watershed lying west of Winthrop Parkway (about 3/4 of the total 85 acres) was within the Sales Creek watershed. They assumed that runoff from the remaining Roughans Point area (about 1/4 of total) east of Winthrop Parkway would be limited to 3 cfs due to restrictive drains and that any appreciable runoff from this area including tidal overtopping would be discharged at the existing Roughans Point pumping station. The designers further pointed out that many of the flooding problems in the Beachmont area (Roughans Point) were caused by tidal inflows and the proposed project would not alleviate that problem. (Ref: "Environmental Impact Report, Flood Control Works, Sales Creek, Revere," Camp, Dresser & McKee, May 1978).

The Sales Creek pumping station, with a capacity equivalent to a watershed runoff rate of about 0.5 inch per hour, allows for a runoff rate of about 32 cfs from about 3/4 of the Roughans Point watershed plus 3 cfs from the remainder, for a total of about 35 cfs from the total Roughans Point with planned maximum gravity discharges to Sales Creek, via a 42-inch diameter conduit, in the order of 35 to 40 cfs. It is also noted that the design capacity of the new Sales Creek pumping statin, equivalent to a watershed runoff rate of about 0.5 inch per hour, is comparable to the 48 cfs capacity of the existing Roughans Point station, equivalent to a runoff rate of about 0.6 inch per hour, from its total 85 acre watershed. The Sales Creek improvements, if completed, and properly operated and maintained, will provide for considerable flood relief within the Sales Creek watershed during normal periods of high interior runoff. However, the system's operation may be impacted during abnormally high storm tides. The minimum top elevation of Bennington Street, the location of the tide gate and pumping station on Sales Creek, is reportedly elevation 9.2 feet NGVD. Therefore, storm tides exceeding this elevation will likely flow over the highway and up Sales Creek. The plan of improvements for Sales Creek were formulated in 1974, prior to the major storm of 1978, and at that time the Boston stillwater tide level had not exceeded 9.2 since December 1959. However, since 1974 the tide has exceeded 9.2 both in January 1979 and most notaby during the major storm such as 1978. A stillwater tide elevation of 9.2 feet NGVD has a present estimated 5-8 percent annual frequency (12-20 year). During a major storm such as 1978, Bennington Street would be overtopped, and though the highways and railway crossings would break incoming waves, levels in Sales

Creek, with its hydraulic improvements, would likely approach stillwater tide level and thus prevent any gravity discharge into Sales Creek from the Roughans Point area.

It is further noted that the original 1974 engineering study recommended dredging an outlet channel in the receiving Belle Isle inlet to permit free discharge during low tide, thus reducing silt accumulation in the improved Sales Creek drainage system. Without dredging it was concluded that sediment accumulation of up to 2 feet in depth in the system would be a continuing problem. Subsequent improvement studies excluded dredging in the Belle Isle inlet, therefore, the future reliability of improved drainage from Roughans Point via Sales Creek, without extensive maintenance is questionable.

Completion of the Sales Creek drainage improvements plus an improved storm drain collector system in the Roughans Point area will provide for improved interior storm drainage but will not eliminate the need for protection against tidal flooding.

A-14. ANALYSIS OF FLOODS

a. General. Four relatively recent and significant flood events at Roughans Point occurred in November 1968, February 1972, February 1978 and January 1979. Based on field interviews and other available information the resulting interior flood levels were determined to be about 8, 8.9, 11.8 and 7.1 feet NGVD, repsectively. Start of damage is about 4 feet NGVD. The resulting interior flood levels were believed to be a function of (a) interior rainfall runoff, (b) salt water intrusion by drain backflow or ground seepage and (c) seawater overtopping. All four events had accompanying high winds and storm rainfall. Pertinent data on the four events are listed in Table A-11. Historically the most serious flooding has resulted from storms with associated overtopping; however, flooding is aggravated by interior runoff and if overtopping were minimized there would still be a potential for minor to moderate street flooding if provisions for improved interior drainage are provided by local interests after improvements are made for protection against tidal overtopping. An analysis was made of experienced and potential storm rainfall-runoff, seawall overtopping, and interior ponding storage capacity in accessing the interior drainage needs at Roughans Point.

b. Storm Rainfall. Twenty-four hour rainfall amounts and maximum hourly rainfall rates recorded at Boston during the four most recent significant flood events, as reported by the National Oceanic and Atmospheric Administration, are listed in Table A-11. Comparative rainfall-frequency-duration data, as reported in U.S. Weather Bureau TP #40 is listed in Table A-12. The experienced storm rainfall and rates were in the order of 2 to 3 inches and 0.3 and 0.5 inch per hour, respectively. In comparison, the all season 20 percent chance (5-year frequency) 24-hour rainfall is 4.0 inches and the 1 hour rainfall rate is reportedly 1.5 inches per hour.

TABLE A-11

RECENT FLOODS AT ROUGHANS POINT
COMPARATIVE HYDROLOGIC DATA

Flood Event	7 Feb 1978	19 Feb 1972	12 Nov 1968	21 Jan 1979
Approx. Interior Level (Ft.,NGVD)	11.8-12	8.8-9	8	7-7.2
Annual Freq. Est. (%)	1	10	25	33
Approx. Flood Volume (Ac-Ft)	210	80	50	30
Ocean Tide (Ft., NGVD)	10.3	9.1	7.7	5.9
Tide Freq., Est. (%)	1	10	80	90+
Max. 1 Hr. Rainfall (In.)	0.2	0.5	0.3	0.4
Storm Rainfall (In.)	2.8/48 hr.	2.5/24 hr.	1.8/24 hr	2.5/24 hr
Rainfall Volume (Ac-Ft)	19	18	12	18
Max. Wind (Fastest-mile, MPH)	61	47	54	33
Wind Direction	NE	NE	NE	SW*

*Wind switched from NE to SW just before predicted high tide.

TABLE A-12

RAINFALL - FREQUENCY - DURATION
USWB TECHNICAL PAPER 40
BOSTON, MASSACHUSETTS

Annual Frequency	Duration in Hours (Inches)				
	1	2	6	12	24
20% (5 yr. freq.)	1.5	2.0	2.8	3.4	4.0
10%	1.8	2.3	3.3	3.9	4.6
2%	2.4	3.1	4.3	5.1	6.0
1% (100 yr. freq.)	2.6	3.3	4.7	5.8	6.8
SPS	3.5	4.8	9.0	10.6	12.4

c. Runoff. Interior runoff and resulting ponding levels at Roughans Point are more a function of rainfall volume than rate. Minimum elevations in the area are about plus 4 feet NGVD, well below normal high tide, and interior runoff must pond or be pumped during high tide periods. Also, during past flood events, though rainfall rates were not intense, rainfall runoff along with overtopping likely accumulated in the interior area even during ebb tides due to limited gravity storm drain capacity. Computed storm runoff and flood volumes stored during recent flood events are summarized in Table A-11. With sufficient gravity drain capacity, ponding would likely be limited to 3 to 4 hours duration - the interval of high tide. Interior runoff volumes were estimated assuming runoff equaled rainfall less an initial 0.2 inch infiltration. Becaue of high water table infiltration losses would be small. Peak runoff rates were estimated by "rational" formula using the maximum 1 hour rainfall rate and a runoff coefficient "C" of 0.7. The resulting maximum runoff rates, during the 4 recent flood events were only 20 to 30 cfs, and maximum 2-hour volumes only about 4 to 7 acre-feet. The 24-hour storm rainfalls represented 12 to 18 acre-feet of runoff volume.

d. Ponding Capacity. Ponding elevation-capacity relations for the Roughans Point interior area were developed by planimetering available two-foot contour maps of the area. The developed storage-capacity curve is shown on Plate A-3. Storage commences at about elevation 4 feet NGVD and storage at elevation 11.8, the 1978 flood level, would approximate 200 acre-feet. Maxium 24 hour rainfall during the 4 recent flood events was not more than 18 acre-feet or less than 10 percent of total interior floodwaters.

e. Overtopping. The analysis of past flood levels, interior flood volumes, and potential rainfall runoff, experienced during 4 recent flood events indicates that ocean water inflow by seawall wave overtopping plus any drain backflow and seepages, probably ranged from 15 to 200 acre-feet and represented 50 to 90 percent of the total interior floodwaters.

f. Pumping Station. A pumping station with a capacity of about 48 cfs, with surface water inlet located on Broad Sound Avenue was built at Roughans Point in 1975. This capacity is equivalent to a runoff rate of 0.6 inch per hour from the 85-acre watershed. This discharge capacity would therefore, be adequate to convey the peak rainfall runoff rates of the four most recent flood events, provided there was no other source of inflow and drainage, and facilities were adequate to convey the runoff to the station. However, inflow rates during the record flood of February 1978, probably in excess of 1,000 cfs, far exceeded the capacity of the station and operating personnel had to be evacuated from the station.

A-15. INTERIOR FLOOD STAGE FREQUENCIES

a. Existing Condition Stage Frequency. An existing condition interior flood stage frequency curve, the basic curve for determining flood damage frequencies, is shown on Plate A-4. This curve was developed by analysis of the history of experienced flood events in recent years, both in numbers and magnitude. The lack of a long term systematic record of historical flood level data did not permit derivation by statistical analysis alone, and the curve was based on both analytical and subjective analysis along with considerable engineering judgement.

Over a 12-year period 1968-1980 the Roughans Point area experienced four significant floods. The greatest one was the February 1978 event with a reported experienced interior flood level of approximately 11.8 feet NGVD, followed by the events of February 1972, November 1968 and January 1979 with reported levels of 9.0, 8.0 and 7.2 feet NGVD, respectively. Simply assigning Weibull plotting positions to these four events per 12 year period would suggest frequencies of 1/13 (8%), 2/13 (15%), 3/13 (23%), 4/13 (31%) for the experienced levels of 11.8, 9.0, 8.0 and 7.2 feet NGVD, respectively. However, the 1978 experienced level of 11.8 was the greates flood level ever known in the Roughans Point area, significantly exceeding any other, and was the result of one of the greatest coastal storms ever experienced along the New England coast based on storm accounts extending over 300-year historic period. Engineering judgment thus ruled out assigning an 8 percent frequency to an event the magnitude of the 1978. Instead, the 1978 interior flood stage was assigned a 1 percent frequency, the frequency of the 1978 storm tide based on a statistical analysis of long term storm tide records for Boston Harbor, including adjustment of historical data for the gradual long term rise in ocean level.

The experienced February 1972 level of 9.0 feet NGVD, was the second highest event in the 12-year period and could justifiably be assigned 2/13 (15%) annual probability Weibull plotting position. This frequency was considered the higher limit for th 1972 event. However, if the 1978 event was treated as a statistical outlier, then the frequency of the 1972 event could be as low as 1/13 (8%). Thus it was concluded that the freqquency of the experienced 1972 stage of 9.0 feet was probably between the limits of 8% and 15%. The frequency of the 1972 event on the finally adopted curve was 10%.

The November 1968 and January 1979 events of 8.0 and 7.2 feet NGVD were the 3rd and 4th events in the 12-year period and these Weibull plotting positions were adopted without adjustment in the development of the adopted interior stage frequency curve.

The plotting positions of the four flood events, after the above adjustments, plus the statement of residents that ponding of 1 to 2 feet (4 to 5 feet NGVD) in the streets occurred annually, was the basis for developing the adopted "existing condition" interior stage frequency curve.

The derivation of the interior stage frequency curve should not be construed as an exact science and the curve should be subjected to review, readjustment and refinement in future design studies, as more flood information or improved methods of determination becomes available.

b. Modified Stage Frequencies. Modified interior stage frequency curves were developed by adjusting "existing condition" curves relative to reductions in overtopping volumes and/or increases in pumping provided by various plans of improvement involving ocean barriers and pumping stations. Modified interior stage frequency curves for a range of barrier configurations and pumping station capacities are shown on Plates A-5, A-5B, and A-5C.

Theoretical design overtopping discharge hydrographs for the existing protection were computed for tidal floods having various maximum ocean stillwater tide levels assuming a sustained onshore wind speed of 60 mph and minimum resulting either wind generated or depth limited, waves. It was found that the theoretical design overtopping volumes computed for existing protection conditions were much greater than the interior flood volumes used in the development of the "existing condition" interior stage frequency curve. For example, with a maximum stillwater ocean level of 10.3 feet NGVD, equal to that of 7 February 1978, the theoretical design overtopping volume was computed to be about 1,500 acre-feet, whereas the volume of overtopping in the 1978 event, estimated from interior high water mark data was in the order of 200 acre-feet. The reason for the difference between experienced and theoretical design overtopping volumes is not fully known but is probably due in part to the fact that: (a) Theoretical design overtopping was based on a sustained onshore windspeed of about 60 mph, whereas winds observed during the 1978 storm were sustained at about 50 mph, and (b) theoretical design overtopping was computed assuming wind and wave direction perpendicular to the structures, whereas, during actual storms the wind and wave attack is probably most frequently at some angle, and (c) the Shore Protection Manual (SPM) indicates that overtopping may be over-estimated when dealing with depth limited waves, and (d) the over-topping guidance in the SPM is incomplete and was developed mainly from small scale model tests which have not been verified by prototype testing. and (e) the geometry of the actual protective structures differs somewhat from those which were used in developing the coefficient graphs in the SPM. As explained in Section A-8, extreme onshore wind and wave conditions can exist over a wide range of stillwater tide levels at Revere. Therefore, under a design condition, the assumption of a sustained 60 mph onshore wind is reasonable. However, in evaluating interior stage frequency where typical wind and wave characteristics and their associated overtopping for a particular stillwater tide level are of interest, a different approach must be taken. Since the observed stillwater tide level is partially a function of windspeed and direction, it would seem probable that on average the greater the stillwater tide the greater the likely windspeed. Using this rationale, adopted overtopping was assumed as a percentage of the theoretical design overtopping with the percentage being that which would provide agreement with the overtopping volumes used to develop the "existing condition" stage frequency curve. The percentage was increased with increasing stillwater tide level, arbituarily assuming that overtopping would approach 100 percent of theoretically computed design overtopping at a stillwater level of 13 feet NGVD, the estimated SPN maximum tide level. The resulting percent of theoretical design overtopping for stillwater tide levels of 8, 9, 10, 11, 12 and 13 feet NGVD was 7, 13, 26, 45, 70 and 100 percent, respectively. This relationship between percent of theoretical design overtopping and stillwater tide level was applied to the theoretical design overtopping volumes computed for the various barrier configurations. When estimated interior flood levels from wave overtopping exceeded minimum height of protection, allowance was made for back flow over the protection in a step routing to arrive at the resulting peak interior elevation.

Storm tide overtopping rate is computed as a function of tide elevation, however, it is known that overtopping does not occur as a continuous rate but occurs in surges with the sinusoidal wave train. When waves break upon a rocky shore the incoming wave overtops the rocks and fills rock controlled tidal pools, but in between the incoming waves some of the water flows back to the sea, occurring as weir flow over the rocks. Similarly, if a walled inclosure is overtopped by waves to the extent that the inclosure is filled with water to the top of the walls, as the wave overtopping continues there will be an increasing rate of backflow between waves, occurring as weir flow over the walls. As overtopping surges continue, the interior elevation will tend to maximize at that level (hydraulic head) required to discharge the average inflow rate back to the sea by weir flow between incoming waves. In estimating interior flood levels at Roughans Point, when accumulated wave overtopping volume exceeded interior capacity to top of protection, allowance was made for weir flow back to the ocean assuming backflow would occur between waves or about 50 percent of the time.

Stage reductions provided by various pumping rates were determined by computing the volume pumped in a 3-hour period (approximate time available for pumping on incoming tide from start of overtopping to peak interior stage) and then subtracting this volume from the no pumping interior volume and stage.

A-16. INTERIOR DRAINAGE DESIGN

a. General. Initially, all structural plans for flood control at Roughans Point included interior drainage improvements as a feature of the projects. Improvements consisted of a trunkline collector drain for conveying interior drainage to gravity outlet and pumping stations. Four different sized interior drainage systems were developed during Stage II studies for cursory cost-benefit analysis. The minimum plan consisted of an improved drainage system with no added pumping at Roughans Point and the other three plans consisted of improvements with added pumping capacities of 50, 100 and 200 cfs for discharging seawall overtopping. Stage II studies demonstrated that adding 100 or 200 cfs pumping capacity for pumping overtopping was not incrementally justified and Stage III studies were limited to evaluating plans with either no added pumping or with 50 cfs added pumping. The currently recommended plan and the one that apparently maximizes net benefits has no added pumping and no interior collector drain improvements. It does provide for an emergency gate closure on the Sales Creek outlet, an improved surface water inlet at the existing pumping station, and a new gravity drain through the line of protection at the existing station. Though an improved storm drain collector in the area would still be desirable it would be a local decision and cost.

b. Interior Drainage Collectors. Improved interior drainage collectors were considered in evaluating various flood control plans for the area. An interior drainage collector, as a minimum, might consist of a 42-inch trunkline storm drain from the existing drain under the Revere Beach Parkway extending east to the southerly end of Broad Sound Avenue (1,800 feet) and then continuing as a 48-inch drain north on Broad Sound Avenue to the existing 48 cfs pumping station (1,000 feet). Such a trunkline drain would have surface inlets and serve as a main outlet for existing feeder drains. It would have a very flat gradient with normal drainage to the west; however, during intense runoff, drainage could be both to Sales Creek and to the Broad Sound Avenue pumping station. As part of the recommended project a sluice gate will be provided at the Sales Creek discharge so that, in the event of high stages in Sales Creek, the gate could be closed and reverse flow would convey all drainage to the Broad Sound pumping station where it would be pumped or discharged by gravity, tide permitting. Assuming conveyance velocities of about 4 feet per second the minimum collector system would have drainage capacity of about 40 to 50 cfs, comparable to existing pumping capacity, under nongravity discharge conditions. Under gravity flow, both to Sales Creek and Broad Sound Avenue, the collector system would have total capacity of 70 to 80 cfs, equivalent to the estimated 20 percent chance (5-year frequency) maximum rainfall-runoff rate. It was concluded that completion of Sales Creek improvements plus an improved Roughans Point collector system would provide residual flood relief comparable to that of an added 50 cfs pumping station at Roughans Point.

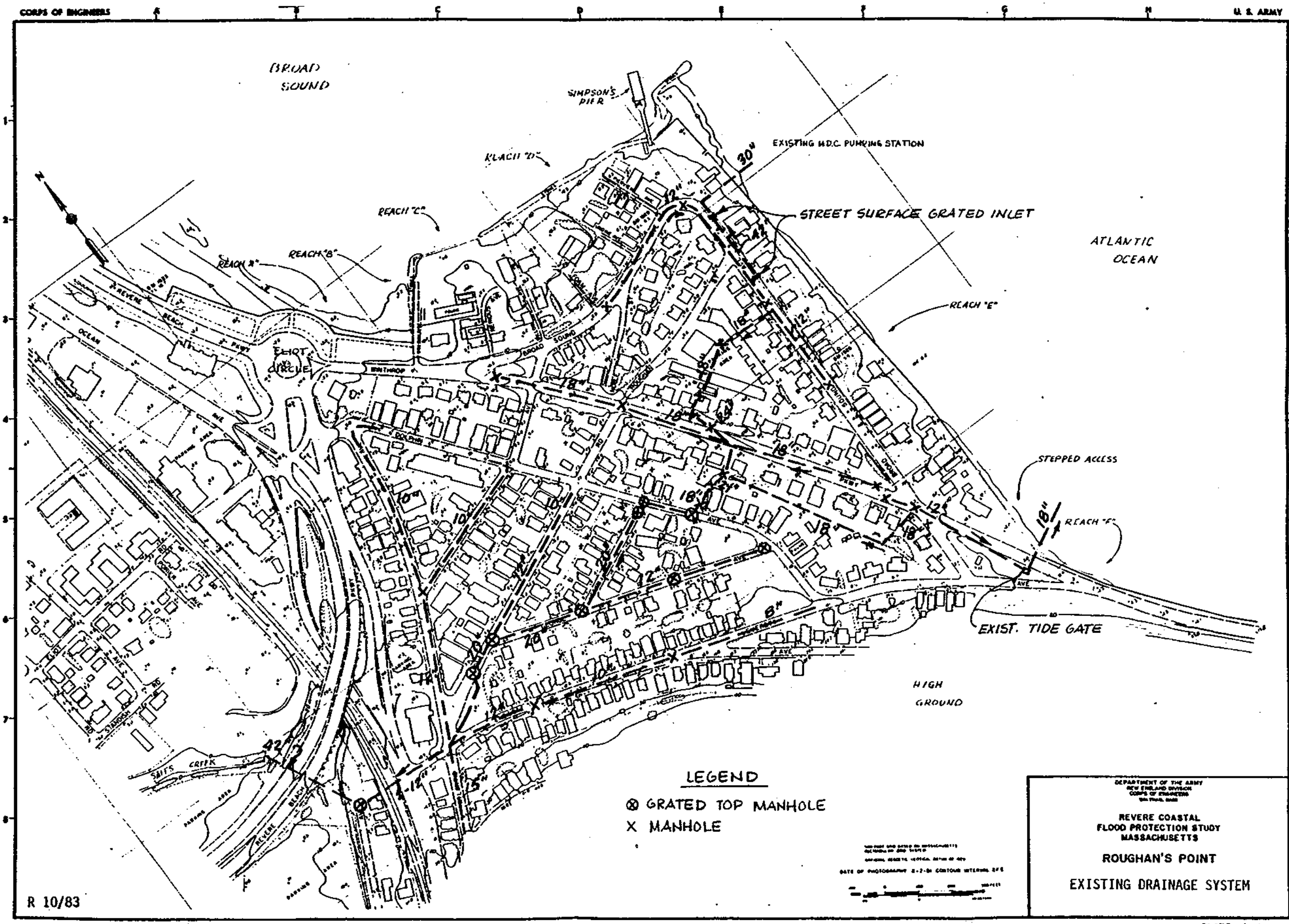
Estimated limits of interior ponding with a Standard Project interior storm runoff and a 100 year frequency storm runoff, with and without interior drainage improvements are shown on Plates A-7 and A-8. Ponding limits are also shown on Plate A-9, for modified Feb. 1978 tidal overtopping plus Standard Project Storm interior runoff.

c. Supplemental Pumping. During Stage II studies interior drainage systems were analyzed with 0, 50, 100 and 200 cfs supplemental pumping capacity. The cost of supplemental pumping was weighed principally against the incremental cost of equivalent seawall improvements. The analysis demonstrated that the incremental benefits for adding a 50 dfs pumping station were just slightly less than the incremental costs, and that was assuming present outlet conditions at Sales Creek. Major improvements in Sales Creek, if dependable, would provide for improved gravity drainage during normal tides and thus further reduce average annual incremental benefits for an added pumping station. However, 50 cfs supplemental pumping was not ruled out since it would serve as a backup to the existing pumping station, and provide for some small amount of wave splash and increased interior discharge capacity. Fifty cfs of supplemental capacity would provide a total pumping capacity of nearly 100 cfs, equivalent to a runoff rate of about 1 inch per hour, the 10 percent annual chance (10-year frequency) maximum rainfall-runoff rate. As stated earlier, the current recommended plan has no added pumping.

The existing pumping station has a total capacity of 48 cfs which is equivalent to a runoff rate of 0.6 inch per hour from the 85 acre interior area. This station has minimal capacity to discharge interior rainfall-runoff provided there are adequate facilities to convey the flow to the station. As part of the recommended project, an improved surface water inlet will be provided at the existing Roughans Point pumping station.

d. Gravity Drain. Included as part of the recommended plan is a 48" emergency gravity drain through the line of protection to be located at the existing Roughans Point station. This drain would serve as an emergency discharge in the event of greater than design interior runoff or wall overtopping and provide a means of rapid evacuation of any accumulated ponding during receding tide.

e. Ponding Levels. Significant ponding in the interior area commences at about elevation +4 feet NGVD, the level of many streets, and appreciable flood damages commence at about elevation +5 feet NGVD. Interior flood damages to residential, commercial and public buildings are in the order of $10,000 at +5 feet NGVD and $80,000 at +6 feet NGVD. Interior flood levels "A", "B" and "C", as defined in EM 1110-2-1410, would be approximately elevations 4, 5 and 6 feet NGVD, respectively. The existing pumping station with a capacity of about 48 cfs would maintain the 10-year frequency interior runoff ponding below level "B" and the 100-year frequency runoff below level "C".



CORPS OF ENGINEERS
U. S. ARMY
BROAD SOUND
SIMPSON'S PIER
EXISTING M.D.C. PUMPING STATION
30"
REACH "D"
REACH "C"
REACH "B"
REACH "A"
STREET SURFACE GRATED INLET
ATLANTIC OCEAN
REACH "E"
ELIOT CIRCLE
STEPPED ACCESS
REACH "F"
EXIST. TIDE GATE
HIGH GROUND
SALTS CREEK
LEGEND
⊗ GRATED TOP MANHOLE
X MANHOLE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHAN'S POINT
EXISTING DRAINAGE SYSTEM
R 10/83

PLATE A-1

CORPS OF ENGINEERS U. S. ARMY

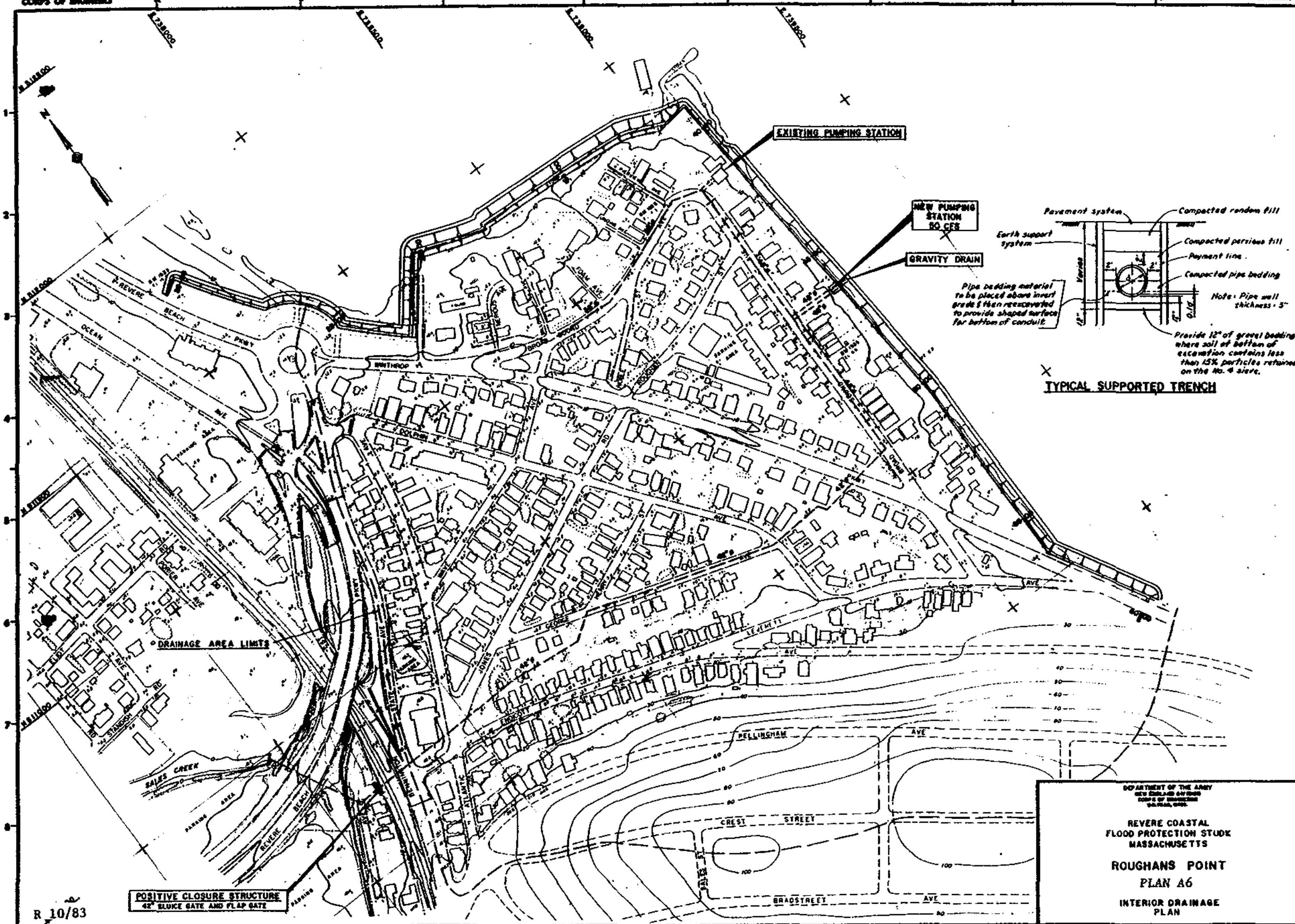
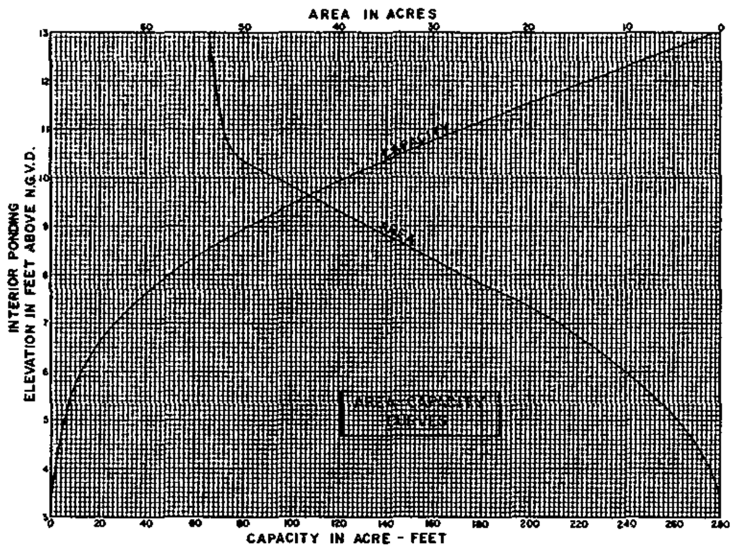
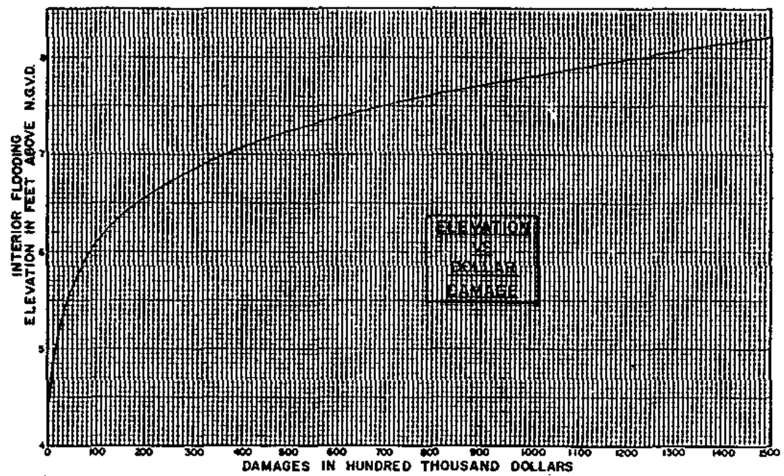
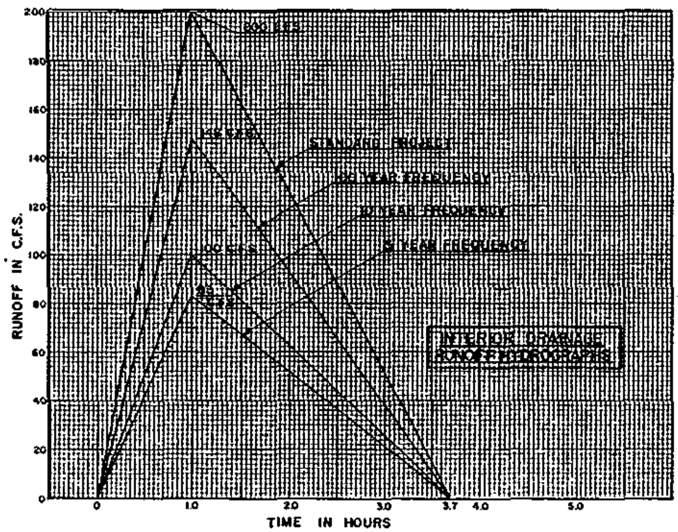
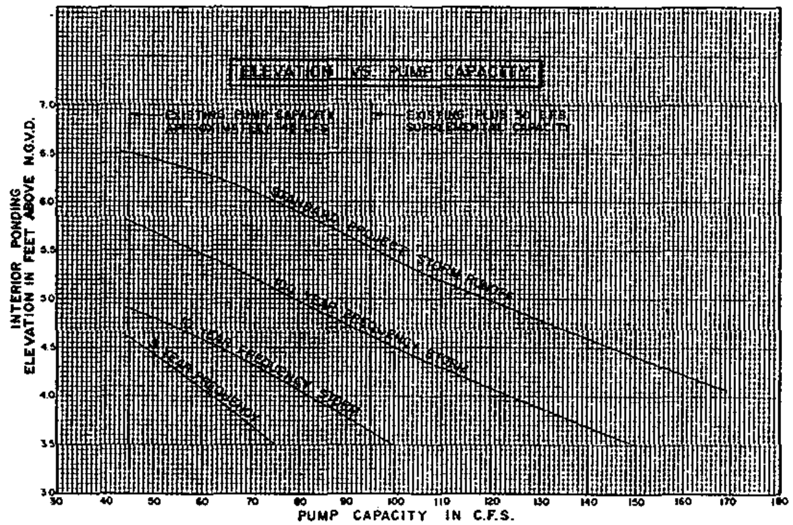


PLATE A-2







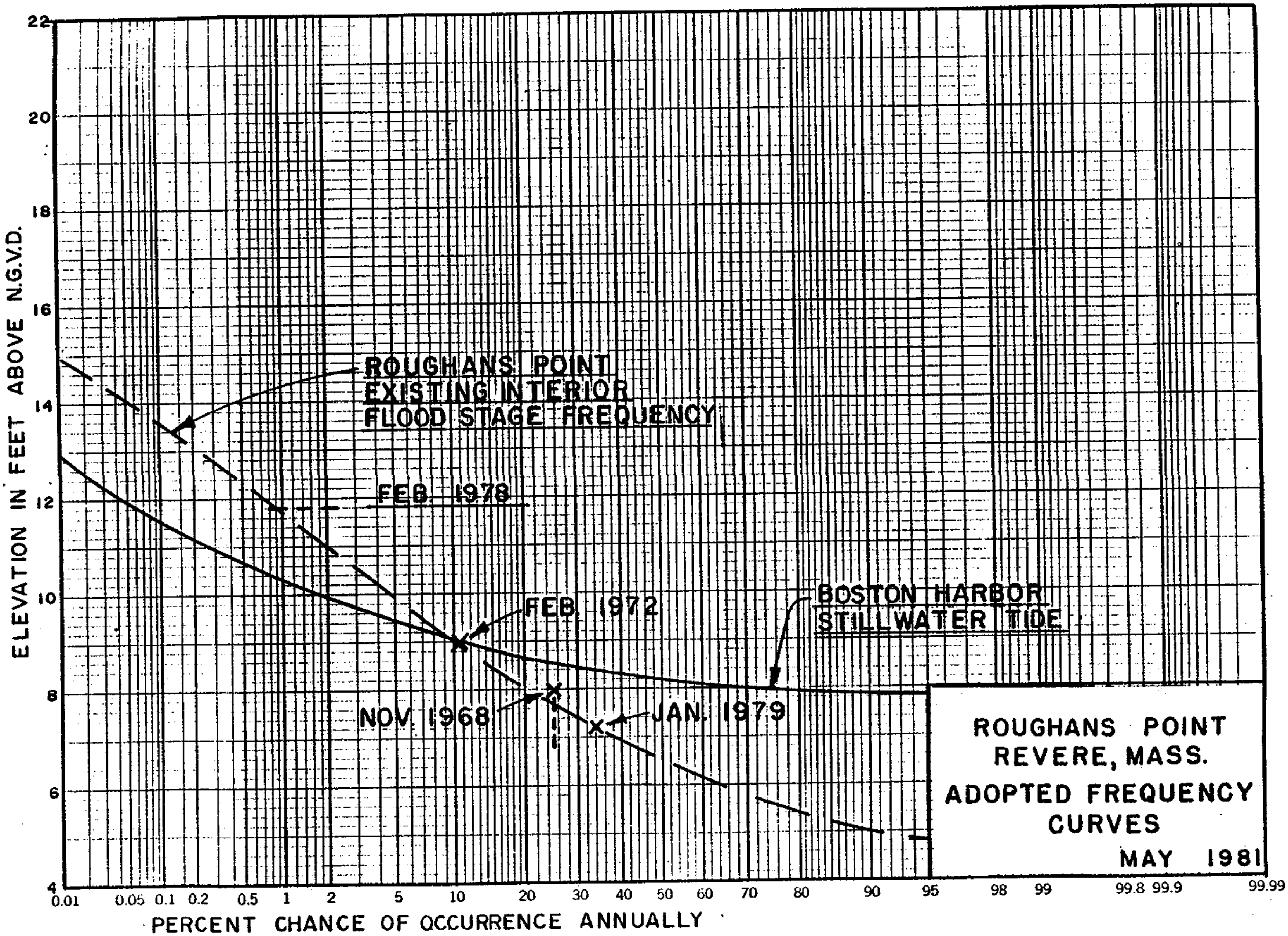


DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

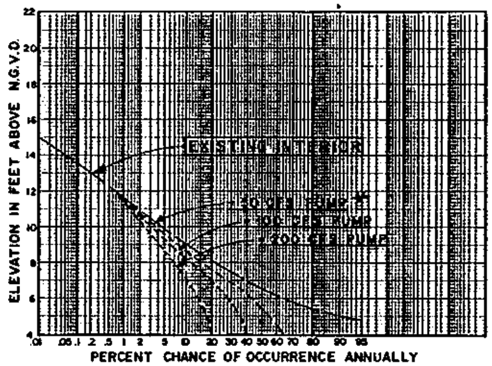
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS

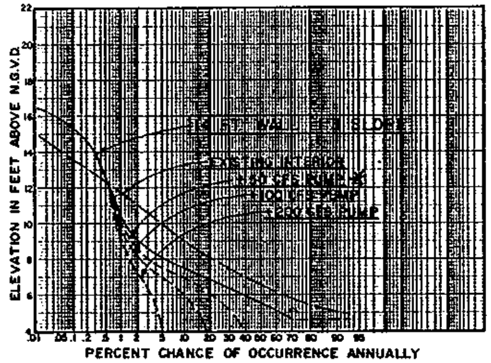
ROUGHANS POINT

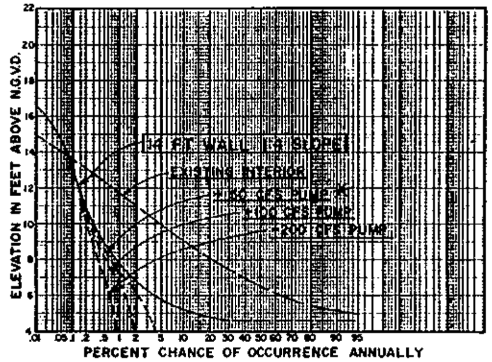
INTERIOR RUNOFF ANALYSIS

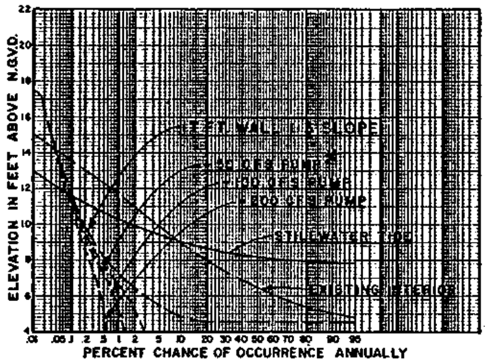


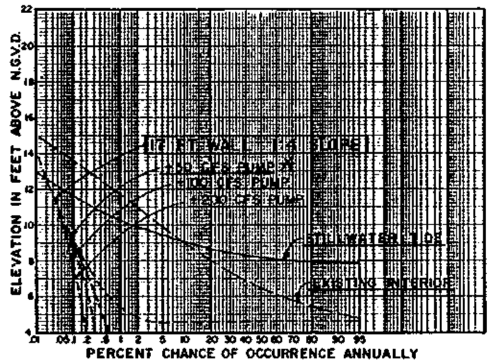
ROUGHANS POINT
REVERE, MASS.
ADOPTED FREQUENCY
CURVES
MAY 1981



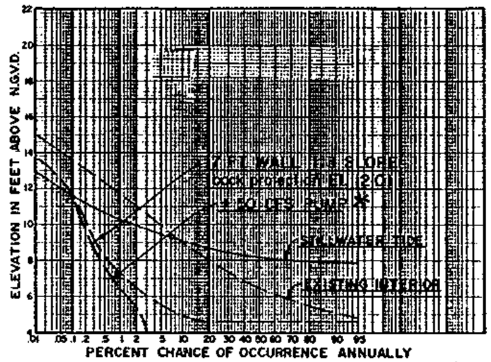








*NOTE: "+50 CFS PUMP" CONDITION CONSIDERED COMPARABLE TO CONDITION WITH SALES CREEK IMPROVEMENTS PLUS A NEW COLLECTOR DRAIN FOR ROUGHANS POINT.



R 10/83

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

REVERE COASTAL
FLOOD PROTECTION STUDY,
MASSACHUSETTS

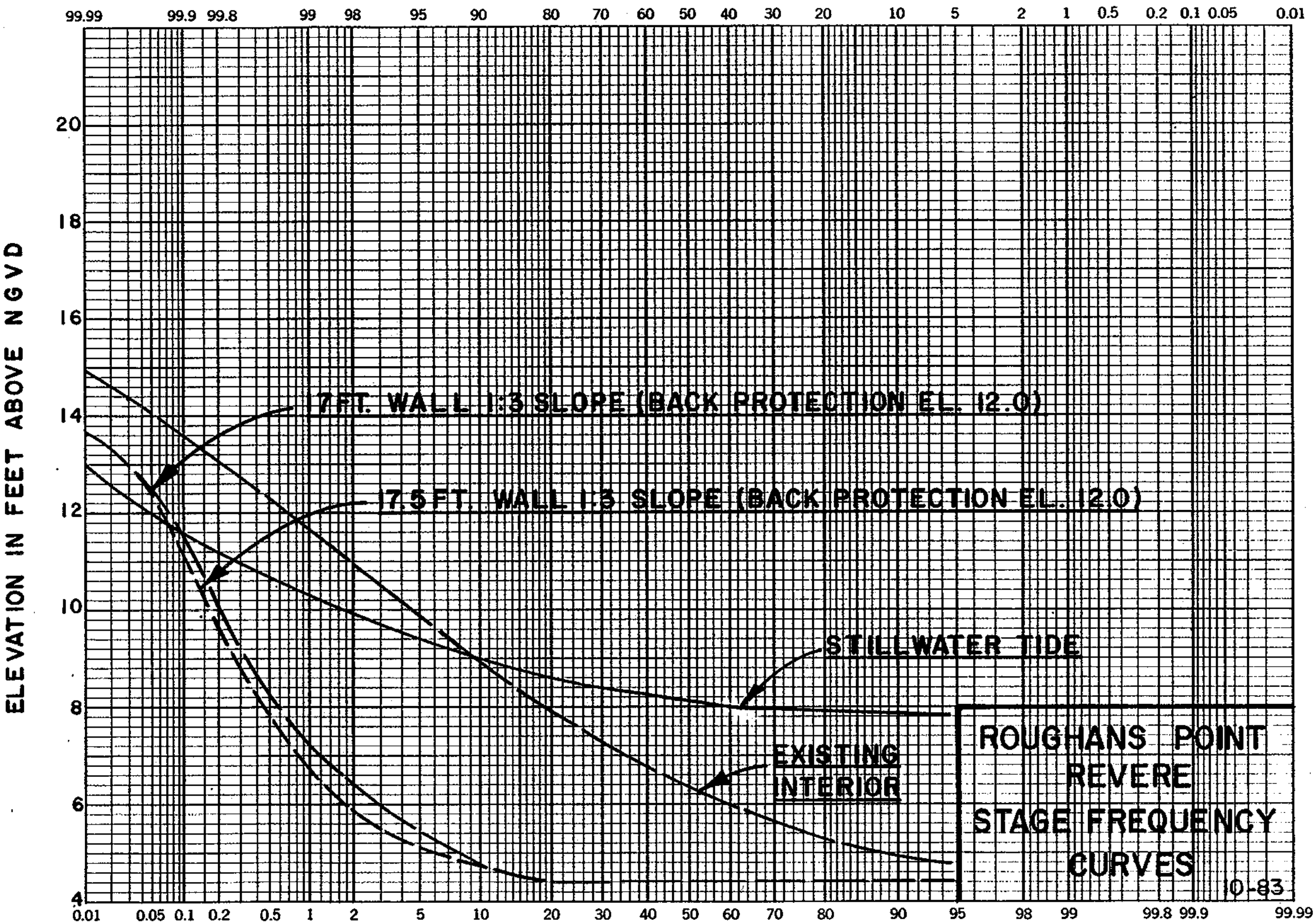
ROUGHANS POINT

MODIFIED
INTERIOR FLOOD STAGE
FREQUENCY CURVES

PLATE A-5

K·E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 8003

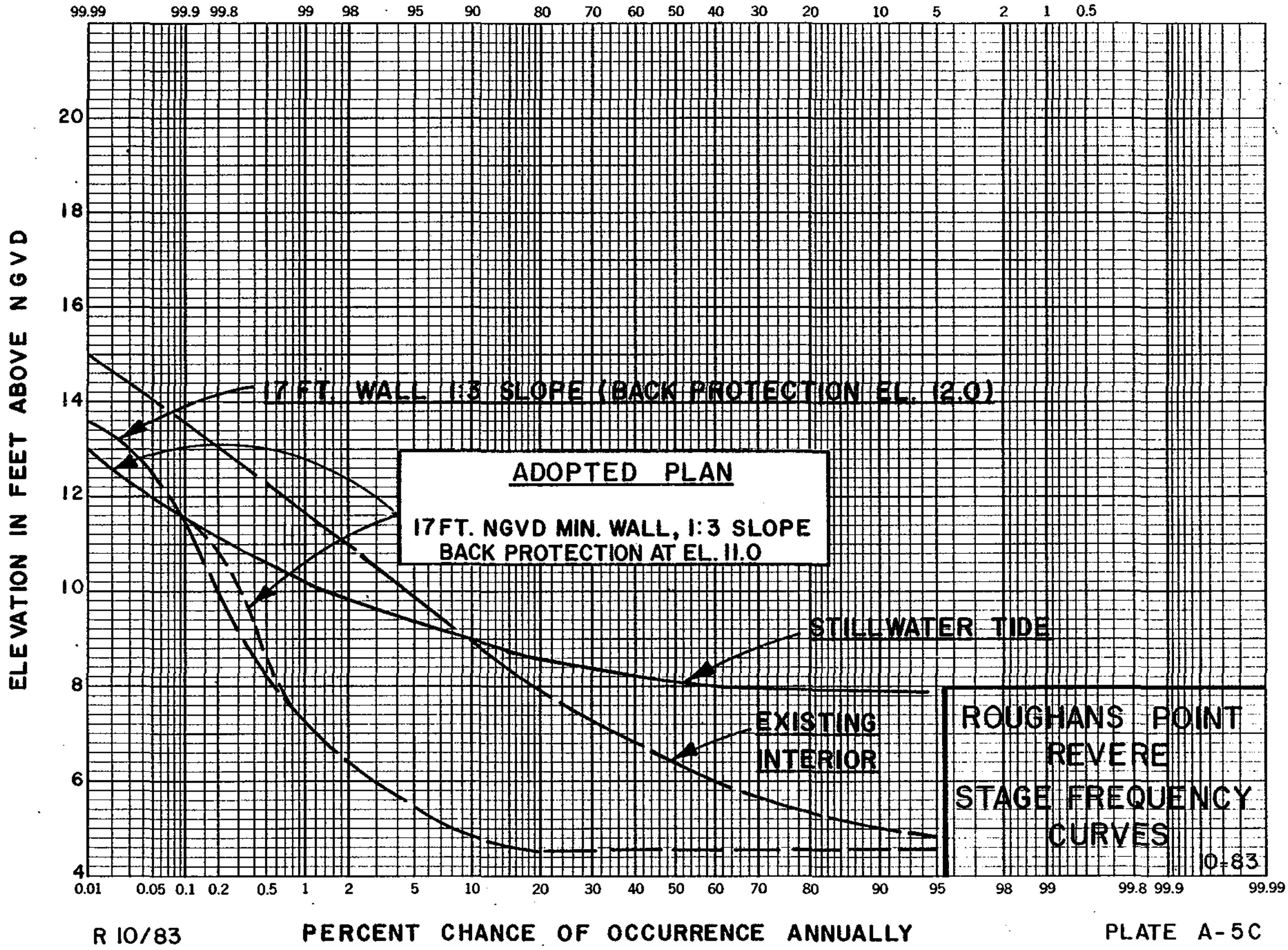


R 10/83

PERCENT CHANCE OF OCCURRENCE ANNUALLY

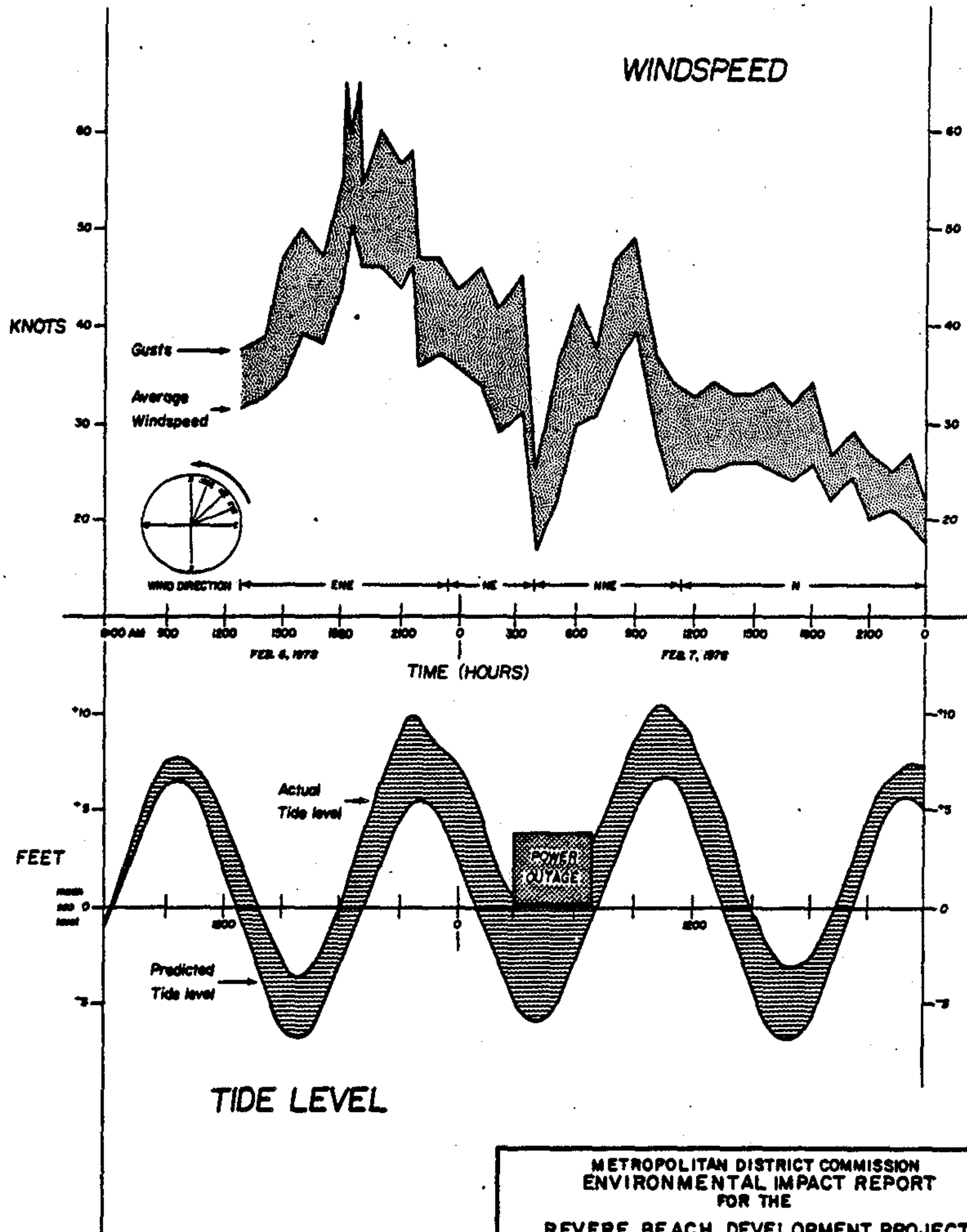
PLATE A-5B

46 8003



R 10/83

PLATE A-5C



METROPOLITAN DISTRICT COMMISSION
ENVIRONMENTAL IMPACT REPORT
FOR THE
REVERE BEACH DEVELOPMENT PROJECT

TIDE LEVEL AND WINDSPEED VS. TIME FOR THE STORM OF FEBRUARY 6 AND 7, 1978.

Camp, Dresser & McKee, Inc.

Alan M. Voorhees & Assoc., Inc. Bolt Beranek & Newman, Inc.

Reprinted from: Environmental Impact Report for the Revere Beach Development Project, Metropolitan District Commission, 1978

PLATE A-6

WIND SPEED PERSISTANCE   SITE LOCATION : BOSTON, MASS.   DATE : 45- 1- 2 TO 65- 1- 1   DIRECTION : NNE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1867 (13)	1235 (16)	569 (22)	303 (25)	156 (29)	43 (33)	12 (38)	4 (44)	1 (49)	0 (0)
2	683 (13)	479 (16)	235 (21)	109 (25)	52 (29)	22 (33)	8 (37)	2 (40)	0 (0)	0 (0)
3	324 (13)	242 (15)	120 (20)	52 (24)	22 (28)	5 (35)	2 (41)	1 (48)	1 (48)	0 (0)
4	149 (12)	105 (14)	44 (18)	17 (23)	6 (28)	2 (31)	0 (0)	0 (0)	0 (0)	0 (0)
5	80 (13)	58 (14)	27 (18)	8 (22)	2 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	56 (13)	37 (15)	16 (21)	9 (23)	4 (26)	1 (30)	0 (0)	0 (0)	0 (0)	0 (0)
7	27 (10)	17 (13)	4 (20)	2 (23)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	16 (13)	15 (14)	5 (18)	2 (23)	1 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	7 (12)	5 (14)	2 (18)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	3 (12)	2 (14)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	3 (14)	3 (14)	1 (21)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	3 (9)	2 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	2 (20)	2 (20)	1 (26)	1 (26)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	1 (16)	1 (16)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	20	20	26	26	29	35	41	48	49	0
MAX DURATION:	18	18	18	13	13	6	3	3	3	0

WIND SPEED PERSISTANCE SITE LOCATION : BOSTON, MASS. DATE : 45- 1- 2 TO 65- 1- 1 DIRECTION : NE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	2087 (14)	1419 (17)	779 (23)	422 (28)	270 (30)	108 (36)	46 (40)	21 (45)	10 (48)	4 (53)
2	752 (14)	562 (17)	307 (21)	167 (25)	82 (30)	31 (35)	16 (38)	5 (44)	2 (47)	0 (0)
3	358 (15)	293 (16)	162 (21)	87 (24)	40 (29)	13 (33)	5 (37)	1 (40)	0 (0)	0 (0)
4	149 (14)	120 (16)	70 (20)	31 (24)	9 (32)	6 (35)	5 (36)	0 (0)	0 (0)	0 (0)
5	83 (14)	64 (16)	38 (20)	18 (24)	8 (29)	1 (52)	1 (52)	1 (52)	1 (52)	1 (52)
6	42 (12)	30 (14)	13 (17)	5 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	26 (15)	24 (16)	17 (18)	4 (26)	3 (28)	1 (31)	0 (0)	0 (0)	0 (0)	0 (0)
8	12 (18)	12 (18)	8 (21)	5 (24)	2 (29)	1 (31)	0 (0)	0 (0)	0 (0)	0 (0)
9	10 (14)	8 (15)	6 (17)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	7 (16)	7 (16)	4 (18)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	4 (16)	4 (16)	3 (17)	1 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	4 (20)	4 (20)	2 (29)	2 (29)	1 (37)	1 (37)	1 (37)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	3 (12)	2 (14)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	1 (8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	1 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	20	20	29	29	37	52	52	52	52	53
MAX DURATION:	18	14	14	12	12	12	12	5	5	5

Plate A-6b

WIND SPEED PERSISTANCE SITE LOCATION : BOSTON, MASS. DATE : 45- 1- 2 TO 65- 1- 1 DIRECTION : ENE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1823 (14)	1237 (17)	635 (23)	348 (28)	209 (31)	99 (36)	35 (40)	21 (43)	4 (49)	1 (56)
2	674 (14)	471 (16)	254 (21)	126 (25)	67 (29)	26 (35)	11 (38)	3 (44)	1 (48)	0 (0)
3	356 (14)	273 (16)	143 (20)	70 (23)	26 (29)	9 (33)	4 (36)	0 (0)	0 (0)	0 (0)
4	187 (14)	142 (16)	77 (20)	39 (23)	13 (28)	4 (33)	2 (36)	0 (0)	0 (0)	0 (0)
5	103 (14)	83 (15)	43 (20)	19 (24)	9 (29)	4 (32)	2 (35)	0 (0)	0 (0)	0 (0)
6	48 (14)	41 (15)	22 (20)	7 (28)	6 (28)	2 (35)	1 (37)	0 (0)	0 (0)	0 (0)
7	31 (12)	25 (14)	9 (17)	3 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	18 (16)	16 (17)	10 (21)	3 (31)	1 (53)	1 (53)	1 (53)	1 (53)	1 (53)	1 (53)
9	7 (13)	6 (14)	2 (18)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	11 (15)	8 (18)	6 (21)	4 (22)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	5 (13)	4 (15)	2 (18)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	3 (10)	2 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	2 (16)	2 (16)	1 (22)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	1 (21)	1 (21)	1 (21)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	1 (12)	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	21	21	23	31	53	53	53	53	53	56
MAX DURATION:	18	18	14	14	10	8	8	8	8	8

Plate A-6c

WIND SPEED PERSISTANCE   SITE LOCATION : BOSTON, MASS.   DATE : 45- 1- 2 TO 65- 1- 1   DIRECTION : E

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1908 (13)	1214 (16)	498 (22)	223 (28)	131 (31)	61 (37)	29 (41)	20 (44)	5 (52)	2 (62)
2	807 (13)	564 (15)	233 (20)	89 (25)	47 (29)	23 (32)	7 (37)	1 (43)	0 (0)	0 (0)
3	410 (12)	307 (14)	101 (20)	38 (24)	18 (28)	6 (32)	2 (37)	0 (0)	0 (0)	0 (0)
4	194 (13)	145 (15)	64 (20)	22 (25)	11 (30)	5 (35)	3 (38)	1 (41)	0 (0)	0 (0)
5	115 (12)	92 (13)	34 (17)	6 (22)	1 (31)	1 (31)	0 (0)	0 (0)	0 (0)	0 (0)
6	85 (12)	66 (14)	18 (18)	8 (23)	4 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	39 (13)	31 (14)	11 (18)	6 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	27 (13)	23 (14)	9 (17)	3 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	12 (13)	11 (14)	4 (17)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	4 (9)	3 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	5 (12)	4 (13)	1 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	3 (17)	2 (22)	2 (22)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	17	22	22	28	31	37	41	44	52	62
MAX DURATION:	12	12	12	12	6	5	4	4	1	1

Plate A-6d

WIND SPEED PERSISTANCE SITE LOCATION : BOSTON, MASS. DATE : 45- 1- 2 TO 65- 1- 1 DIRECTION : ESE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1982 (12)	1219 (15)	403 (20)	137 (24)	60 (29)	18 (35)	6 (37)	1 (40)	0 (0)	0 (0)
2	852 (12)	572 (14)	205 (18)	62 (24)	25 (28)	6 (33)	2 (37)	0 (0)	0 (0)	0 (0)
3	452 (12)	324 (13)	102 (17)	26 (22)	4 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	217 (12)	164 (14)	50 (18)	17 (25)	7 (32)	3 (39)	1 (54)	1 (54)	1 (54)	1 (54)
5	98 (10)	66 (13)	16 (16)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	63 (12)	53 (12)	7 (20)	4 (22)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	27 (10)	20 (13)	3 (17)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	16 (13)	13 (14)	6 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	9 (9)	5 (12)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	3 (10)	1 (16)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	3 (10)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	1 (12)	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	1 (12)	1 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	13	16	20	25	32	39	54	54	54	54
MAX DURATION:	22	22	10	7	6	4	4	4	4	4

Plate A-6e

WIND SPEED PERSISTANCE SITE LOCATION : BOSTON, MASS. DATE : 45- 1- 2 TO 65- 1- 1 DIRECTION : SE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1654 (10)	922 (14)	249 (18)	65 (24)	22 (29)	6 (32)	1 (38)	0 (0)	0 (0)	0 (0)
2	755 (10)	425 (14)	120 (18)	28 (25)	10 (32)	3 (44)	1 (71)	1 (71)	1 (71)	1 (71)
3	361 (10)	231 (13)	52 (17)	8 (22)	2 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	160 (10)	96 (13)	24 (16)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	72 (10)	54 (12)	8 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	34 (12)	27 (13)	6 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	10 (12)	8 (13)	1 (22)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	4 (9)	2 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	10 (9)	4 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	3 (9)	2 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	2 (8)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	12	14	22	25	32	44	71	71	71	71
MAX DURATION:	11	11	7	7	3	2	2	2	2	2

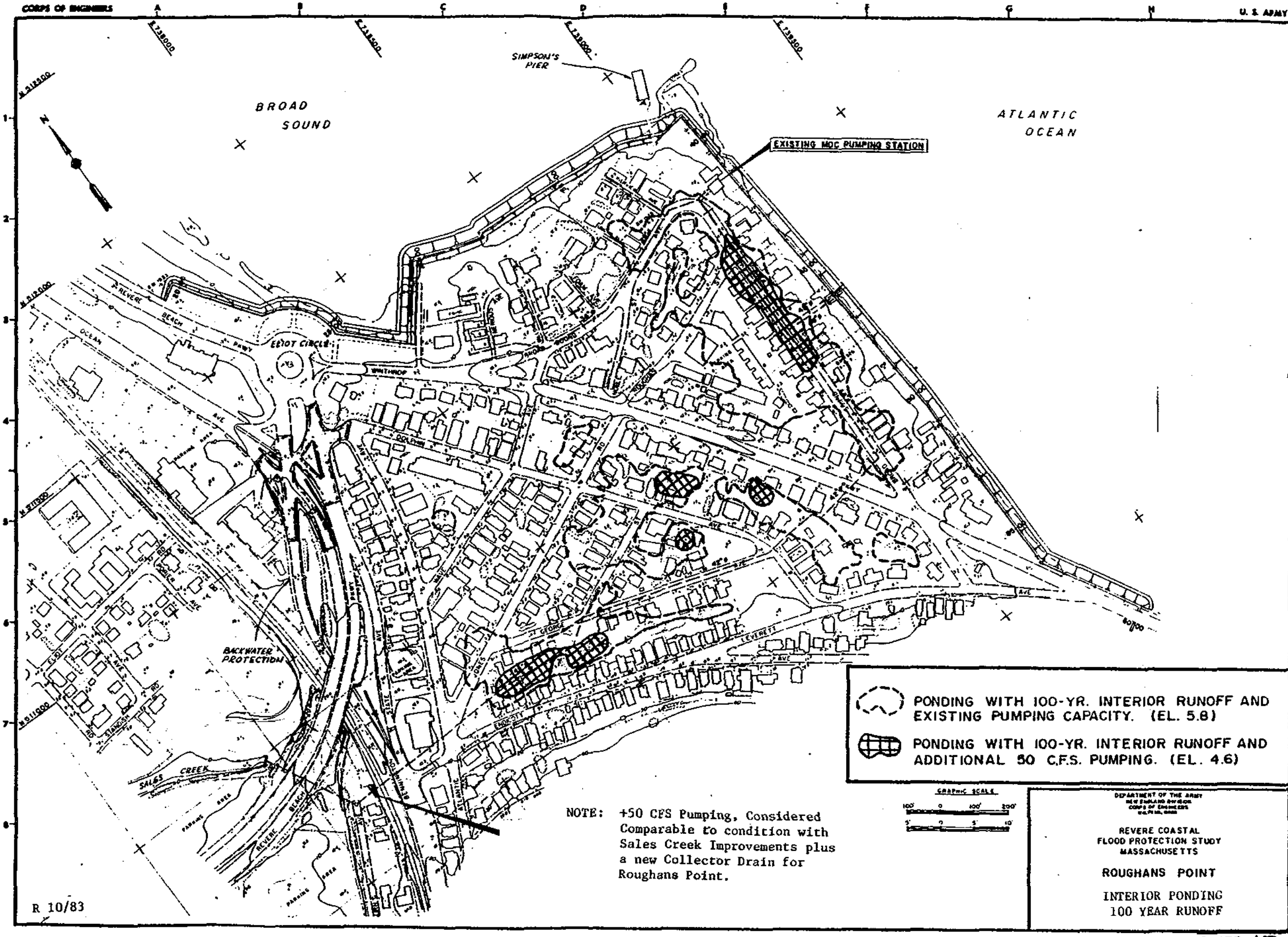
Plate A-6f

WIND SPEED PERSISTANCE SITE LOCATION : BOSTON, MASS. DATE : 45- 1- 2 TO 65- 1- 1 DIRECTION : SSE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

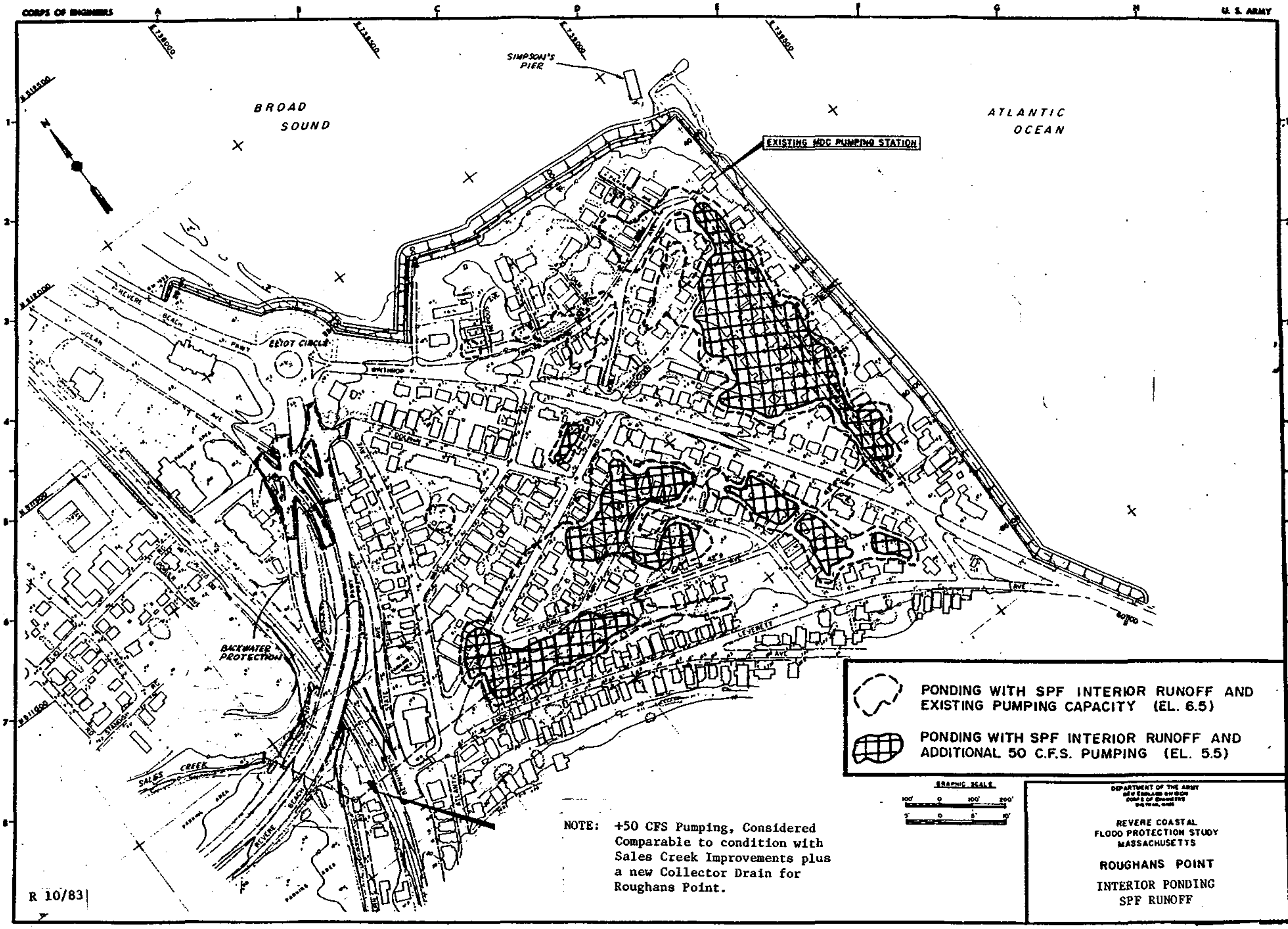
CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	1457 (10)	690 (14)	193 (20)	62 (24)	28 (29)	9 (33)	2 (38)	0 (0)	0 (0)	0 (0)
2	650 (9)	287 (13)	68 (18)	23 (23)	7 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	269 (9)	133 (13)	28 (20)	13 (23)	4 (29)	1 (37)	1 (37)	0 (0)	0 (0)	0 (0)
4	119 (9)	57 (12)	9 (17)	2 (23)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	65 (10)	38 (13)	10 (17)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	21 (9)	13 (12)	1 (22)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	13 (10)	9 (12)	2 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	5 (10)	4 (12)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	5 (9)	3 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	2 (12)	2 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	1 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	1 (17)	1 (17)	1 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	17	17	22	24	29	37	38	0	0	0
MAX DURATION:	17	17	17	6	4	3	3	0	0	0

Plate A-6g



CORPS OF ENGINEERS
U. S. ARMY
SIMPSON'S PIER
BROAD SOUND
ATLANTIC OCEAN
EXISTING MDC PUMPING STATION
ELIOT CIRCLE
REVERE BEACH PKWY
OCEAN AVE
WINTHROP
DOLPHIN
GEORGE
LEVERETT AVE
ENDICOTT
SALES CREEK
BACKWATER PROTECTION
PONDING WITH 100-YR. INTERIOR RUNOFF AND EXISTING PUMPING CAPACITY. (EL. 5.8)
PONDING WITH 100-YR. INTERIOR RUNOFF AND ADDITIONAL 50 C.F.S. PUMPING. (EL. 4.6)
NOTE: +50 CFS Pumping, Considered Comparable to condition with Sales Creek Improvements plus a new Collector Drain for Roughans Point.
GRAPHIC SCALE
DEPARTMENT OF THE ARMY
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHANS POINT
INTERIOR PONDING
100 YEAR RUNOFF
R 10/83

PLATE A7


CORPS OF ENGINEERS
U. S. ARMY
SIMPSON'S PIER
BROAD SOUND
ATLANTIC OCEAN
EXISTING MDC PUMPING STATION
ELIOT CIRCLE
REVERE BEACH PKWY
OCEAN AVE
LEVERETT AVE
BACKWATER PROTECTION
SALES CREEK
PONDING WITH SPF INTERIOR RUNOFF AND EXISTING PUMPING CAPACITY (EL. 6.5)
PONDING WITH SPF INTERIOR RUNOFF AND ADDITIONAL 50 C.F.S. PUMPING (EL. 5.5)
GRAPHIC SCALE
NOTE: +50 CFS Pumping, Considered Comparable to condition with Sales Creek Improvements plus a new Collector Drain for Roughans Point.
REVERE COASTAL FLOOD PROTECTION STUDY MASSACHUSETTS
ROUGHANS POINT
INTERIOR PONDING SPF RUNOFF
R 10/83

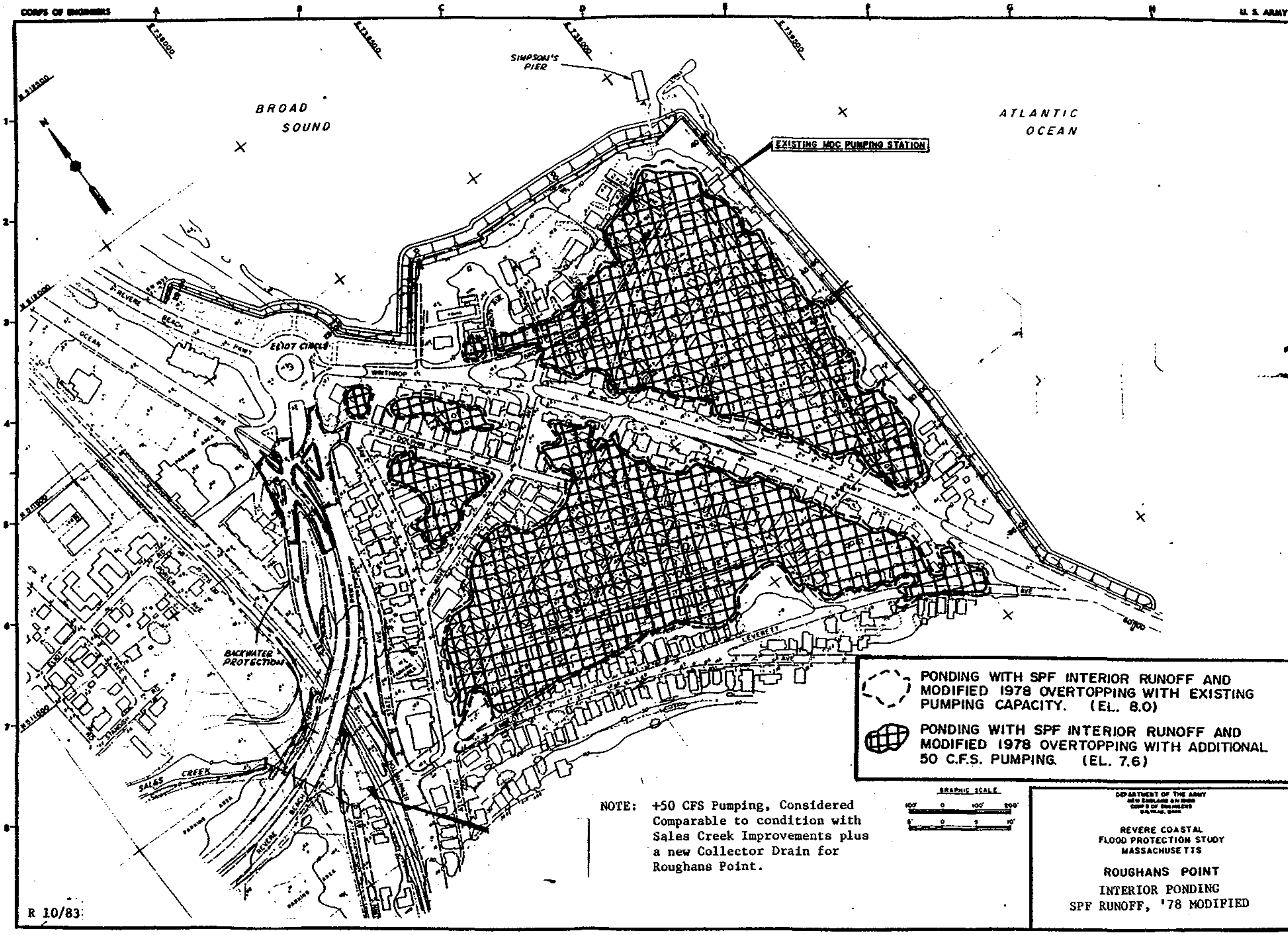

CORPS OF ENGINEERS
U. S. ARMY
BROAD SOUND
ATLANTIC OCEAN
SIMPSON'S PIER
EXISTING MDC PUMPING STATION
ELIOT CIRCLE
WINTHROP
OCEAN
REVERE BEACH PKWY
BACKWATER PROTECTION
SALES CREEK
EVERETT AVE
PONDING WITH SPF INTERIOR RUNOFF AND MODIFIED 1978 OVERTOPPING WITH EXISTING PUMPING CAPACITY. (EL. 8.0)
PONDING WITH SPF INTERIOR RUNOFF AND MODIFIED 1978 OVERTOPPING WITH ADDITIONAL 50 C.F.S. PUMPING. (EL. 7.6)
NOTE: +50 CFS Pumping, Considered Comparable to condition with Sales Creek Improvements plus a new Collector Drain for Roughans Point.
GRAPHIC SCALE
DEPARTMENT OF THE ARMY
REVERE COASTAL FLOOD PROTECTION STUDY MASSACHUSETTS
ROUGHANS POINT
INTERIOR PONDING
SPF RUNOFF, '78 MODIFIED
R 10/83

PLATE A-9

REVERE FLOOD CONTROL PROJECT

ROUGHANS POINT

STAGE III

GEOTECHNICAL CONSIDERATIONS

APPENDIX B

US Army Corps of Engineers
New England Division
Engineering Division
Geotechnical Engineering Branch
Waltham, Massachusetts 02254

REVERE FLOOD CONTROL PROJECT
ROUGHANS POINT, STAGE III - GEOTECHNICAL CONSIDERATIONS

GEOTECHNICAL ENGINEERING BRANCH

FEBRUARY 1982
Revised Oct. 1983

INDEX

PLATES

REVERE FLOOD CONTROL PROJECT
ROUGHANS POINT, STAGE III - GEOTECHNICAL CONSIDERATIONS

February 1982 (Rev. Oct. 1983)

1. Topography. The Roughans Point area is located within the Seaboard Lowland section of the New England physiographic province. The area is characterized by a relatively flat, seaward-sloping region, predominantly under 100 feet NGVD (National Gmodetic Vertical Datum) elevation. GLacial features, such as drumlins, usually provide higher relief in the area.

2. Geology.

a. Surficial. In the regions of higher elevation, the overburden consists primarily of glacially derived material. Till, an unsorted mixture of clay, sand, gravel, and boulders is common and generally overlies bedrock. Glacially-derived, stratified sand and gravel deposits are occasionally found overlying the till. A relatively recent sequence of lagoonal silts and clays, peat and organic silt, and beach deposits of sand and gravel overlies the glacial deposits.

b. Bedrock. The principal bedrock type in the area is the Cambridge slate, also known as the Cambridge argillite. It is a thinly-bedded to massive, sedimentary rock composed of clay-sized particles. Igneous intrusions and volcanics are also found in this region. The available subsurface informstion indicates that bedrock along the proposed coastal flood protection alignment is found to be deeper than 30 to 40 feet below ground surface.

3. Seismicity. The Roughans Point area is located witiin Zone 3 of the seismic zone map of the United States. This is a modification of the seismic risk map developed by the Environmental Science Administration and the Coast and Gmodetic Survey and is contained in Engineering Regulation 1110-2-1806 dated April 1977. In accordance with this directive and ETL 1110-2-256 dated 24 June 1981, a coefficient of 0.10g is recommended for use in any evaluation of seismic stability of structures in final design.

4. Foundation Investigations. No subsurface explorations or soil testing program were conducted by the New England Division for this project. Thirty-seven (37) logs of borings performed for the Massachusetts Department of Public Works (MDPW), the Metropolitan District Commission (MDC), and other interests were used in analyzing foundation conditions. The Plan of Explorations is shown on Plate B-1. Twenty-seven (27) of the borings were completed prior to 1936. The original plan and profile of these explorations are shown on Plate B-2. The remaining ten borings were completed in 1962, 1973, and 1977. The graphic logs completed prior to 1936 give a general soil description but do not indicate any blow count information. The graphic logs completed in 1962, 1973, and 1977 are more complete and indicate the sampling method and blow count information. A subsurface exploration and soil testing program is required prior to final

design of the proposed coastal flood control project to further identify the foundation parameters to enable refinement of the proposed designs.

5. Foundation Conditions.

a. General. Evaluation of the existing boring logs indicates that the soil profile in the proposed project area is fairly consistent. In a general sense, the thirty-seven graphic logs indicate in order of increasing depth, from one to twenty feet of surficial sand and gravel with boulders (fill), from six to twenty-four feet of peat or peat with silt, from 0 to twenty-four feet of medium to hard, blue clay, and an undetermined thickness of compact, gravelly, clayey sand. A complete geologic profile is depicted as Plate B-3.

b. Revetment Reach (Station 20+00 to 60+00). The average ground elevation at the toe of the proposed revetment ranges from 0 to +5 feet NGVD. The available graphic boring logs indicate that surficial sand, gravel, and boulders are found above approximately 0 feet NGVD, various thicknesses of peat and peat and silt are found between elevations +2 and -24 feet NGVD, medium to hard clays are found between -10 and -40 feet NGVD, and an undetermined thickness of compact, gravelly clayey sand below the clay layer.

c. Pumping Station. Two (2) explorations are adjacent to the existing pumping station site. The graphic boring logs indicate 1 to 3 feet of sand, gravel, and boulders between elevation +1 and -3 feet NGVD, overlying 8 to 12 feet of peat and peat and silt that extends to elevation -12 feet NGVD. Below the peat is a 10-foot strata of medium to hard clay between elevation -10 and -23 feet NGVD overlying an undetermined depth of compact clayey sand.

d. Interior Drainage System. The ground elevation along the existing interior drainage system ranges between elevation +10 feet and +4 feet NGVD.

The available subsurface information indicates that bedrock is not encountered; however, the bottom of the silt and peat strata is indicated to be as deep as elevation -11 feet NGVD or deeper.

e. Backwater Protection. The proposed backwater protection system consists of constructing 200 linear feet of earth berm with an average height of approximately one foot. The available boring logs indicate the southerly reach at the intersection of Bennington and State Street to be underlain mostly with dense sands and gravels. The more northerly reach indicates 10 to 12 feet of sand, gravel, and cobbles overlying seven feet of peat and silt. Below the peat and silt strata is an undetermined depth of compact sand and gravel with cobbles and boulders.

6. Groundwater Conditions. Groundwater levels at the proposed coastal flood protection project are controlled by tidal action. The normal tide range at Roughans Point fluctuates between elevation -4.6 feet NGVD and +4.9 feet NGVD.

7. Design Considerations. In view of the lack of detailed design plans for the existing structures, visual observation of the site, inability of the existing protection system to meet current Corps of Engineers design criteria, and the assumed foundation conditions, the existing protection system is considered unstable for the design stillwater elevation and wave height being considered under this study.

The available subsurface information, which consists of thirty-seven (37) graphic boring logs and no soil test data, is inadequate for final design. The available information indicates poor foundation conditions consisting of six to twenty-four feet of peat or peat with silt from one to twenty feet below the ground surface. The proposed preliminary design is subject to change when a more detailed subsurface exploration and soil testing program is completed. More detailed soil parameters and a more complete mapping of the soil profile along the proposed project alignment will further define excavation and fill limits (to remove and replace unsuitable soils), the need for pile foundations, and the height to which the revetment section will have to be overbuilt in anticipation of foundation settlements.

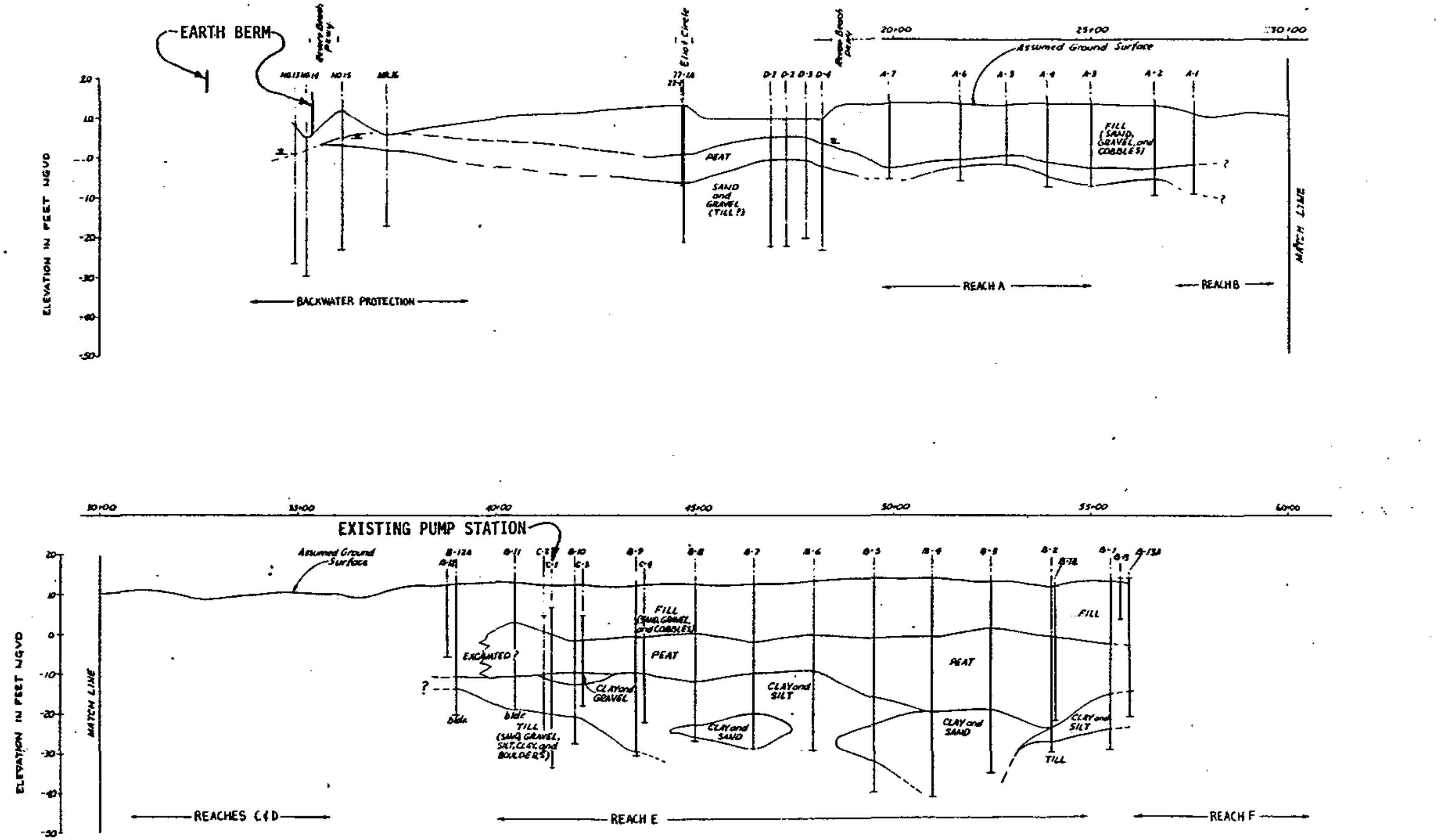
8. Construction Materials. Anticipated construction materials will be sands and gravels for fill materials, concrete aggregate, and rock for the stone berms. All of these materials are available from commercial suppliers within a 40-mile radius of the project area.

9. Conclusions and Recommendations.

a. Based upon existing data, the proposed structural flood protection system, which includes 4,080 feet of rubble revetment, a pump intake and gravity drain, and 200 feet of earth berm appears feasible to construct at Roughans Point.

b. Poor foundation conditions exist throughout the project area with up to 24 feet of past in some locations.

c. A subsurface investigation program and a soils testing program will be necessary to accurately define foundation conditions prior to final design.



BORING SERIES	NOTES YEAR	ORGANIZATION
"A"	1910	MASS. DEPT. PUB. WKS. (?)
"B"	1936	MASS. DEPT. PUB. WKS.
"C"	1973	MET. DIST. COMM.
"D"	1962	NEW ENG. TEST BORING CO.
"NQ"	1932	MET. DIST. COMM (?)
"77"	1977	FAY, SPOFFORD, & THORNDIKE

LEGEND

- Water Level (Tidal)
- Assumed material boundary
- Material boundary defined by boring
- ? Lack of correlatable subsurface data
- Boring indicating number and depth.

GRAPHIC SCALES

HORIZONTAL 100' 0 100' 200'

VERTICAL 10' 0 10' 20'

NATIONAL GEODETIC VERTICAL DATUM OF 1929

0 M.L.W. = -4.6 FEET N.G.V.D.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS

REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS

ROUGHANS POINT
PROFILE OF EXPLORATIONS

R 10/83

PLATE B-1

CORPS OF ENGINEERS U. S. ARMY

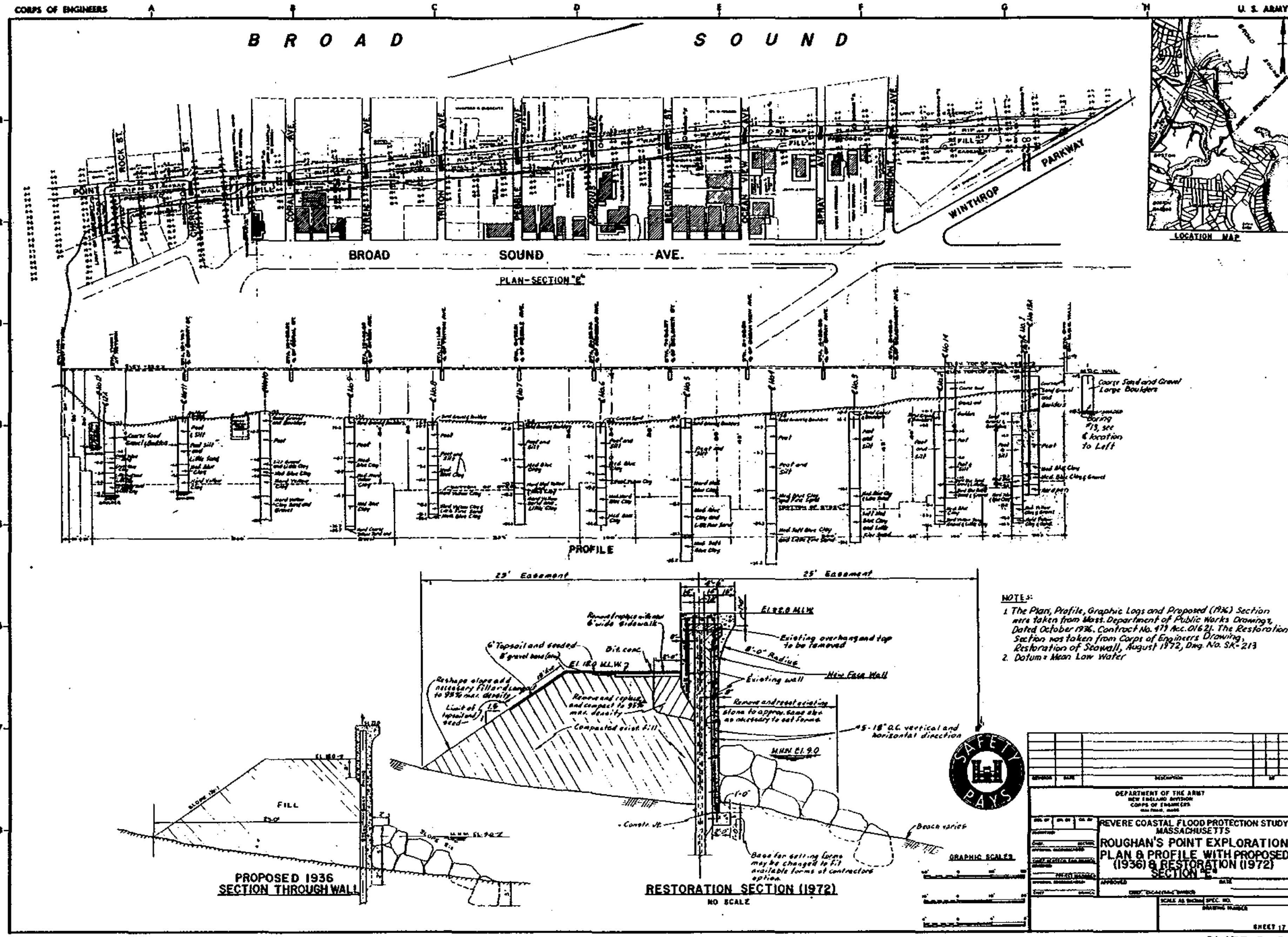


PLATE B-2

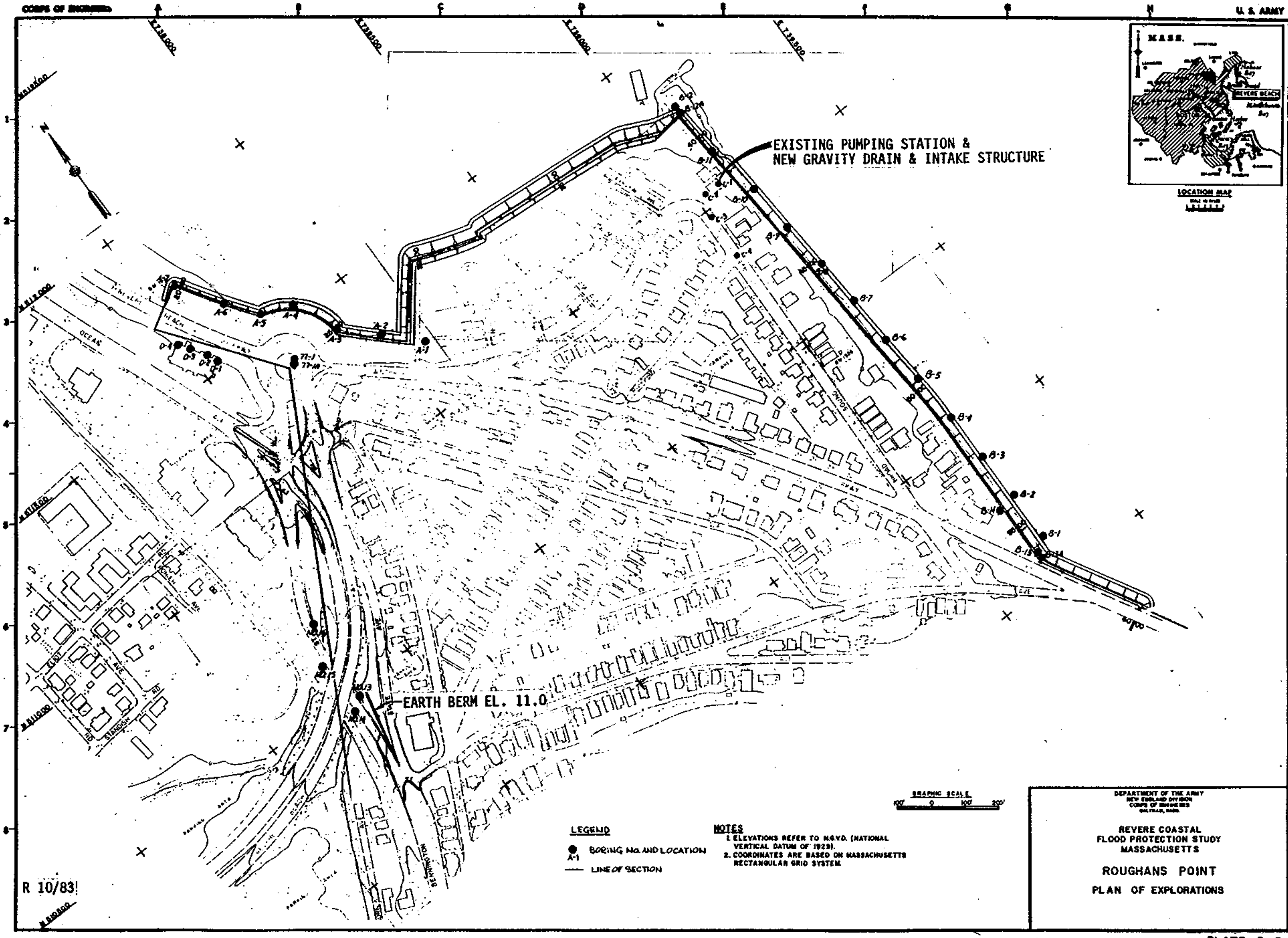

U. S. ARMY
EXISTING PUMPING STATION &
NEW GRAVITY DRAIN & INTAKE STRUCTURE
REVERE BEACH
LOCATION MAP
EARTH BERM EL. 11.0
R 10/83
GRAPHIC SCALE
100' 0 100' 200'
LEGEND
BORING No. AND LOCATION
A-1
LINE OF SECTION
NOTES
1. ELEVATIONS REFER TO N.G.V.D. (NATIONAL VERTICAL DATUM OF 1929).
2. COORDINATES ARE BASED ON MASSACHUSETTS RECTANGULAR GRID SYSTEM.
DEPARTMENT OF THE ARMY
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHANS POINT
PLAN OF EXPLORATIONS

PLATE B-3

<u>APPENDIX C</u>

<u>DESIGN & COST</u>

APPENDIX C

DESIGN & COST ESTIMATE

TABLE OF CONTENTS

LIST OF PLATES

ROUGHANS POINT, REVERE, MASSACHUSETTS

A. PERTINENT DATA

1. Roughans Point

a. Purpose — Coastal Flood Protection

b. Location

State	Massachusetts
County	Suffolk

c. Level of Protection

Frequency	(see Main Report)

d. Rock Berms

Type	Armor Stone
Elevation	EL. 14.0 & 17.0 ft. NGVD
Width (top)	5 feet, 10 feet
Length	4080 feet
Height	17 feet I
Acres Displaced	5 acres
Seaward Slope	1V on 3H
Landside Slope	1V on 2H
Access Steps	Various Locations

e. Concrete Cap

Type	Reinforced
Elevation	17.0 N.G.V.D.
Width	2.0 feet
Length	805 feet
Height	1.7 feet

f. Backwater Protection

Type	Earth Berm
Elevation	11.0 N.G.V.D.
Length	200 feet
Height	1.0 feet

g. Interior Drainage

Type	Gravity Drain
Size	48"Ø
Length	100 L.F.
Control Gates	

h. Existing Pumping Station

Location	sta. 41+50
Size	30 feet x 40 feet
Capacity	48 c.f.s.
Power Source	local, diesel generator

i. Principal Quantities

Excavation General	51,000 c.y.
Armor Stone	59,000 c.y.
Underlayer stone	27,000 c.y.
Bedding stone	14,300 c.y.
Gravel	21,500 c.y.

j. Estimated Project Costs

08. Backwater Protection (Roads)	$ 10,000
10. Shore Protection (Seawalls)	5,444,000
13. Interior Drainage	363,000
Total Estimated Construction Cost	$5,817,000*

*Lands and Damages, Engineering and Design, Supervision and Administration costs not included.

B. STRUCTURAL PLAN

The structural plan provides variable level of protection to Roughans Point and consists of an armor stone revetment from a point 400 feet north of Eliot Circle southerly along the shore to a point 200 feet south of the intersection of Winthrop Parkway and Leverett Avenue. A sandbag closure across Winthrop Parkway is included here at this point. The plan calls for backwater protection by constructing an earth berm in the median between State Road and Bennington Street which will tie to high ground at the Revere Beach Parkway embankment to the north. A 50 foot sand bag closure would extend the median to the south to tie to high ground.

Interior drainage improvements will consist of the existing pumping station and a new intake structure, gravity drain and two sluice gates. Plate C-1, depicting the general plan, follows.

C. DESCRIPTION OF PROPOSED STRUCTURES AND IMPROVEMENTS

1. General

The following paragraphs provide a detailed description of the project's major construction features.

2. Armor Stone Revetment

Section Sta. 19+20 to Sta. 27+25 is shown on Plate C-6 and consists of adding 1.7 feet to the top of the existing concrete wall, bringing the top elevation to 17.0 ft. N.G.V.D. An armor stone revetment is located in front of the existing wall. This revetment will have a top width of 5 feet at elevation 14.0 ft. N.G.V.D. and a seaward slope of 1 on 3 down to the existing ground surfzce with a 10 foot toe. A 6 foot thick armor stone layer will cover a 3 foot layer of underlayer stone. This covers 1.5 feet of bedding stone placed on 1.5 feet of gravel.

The reach from sta. 27+25 to sta. 29+95 is shown on Plate C-6 and consists of steel sheet piling as a "cut-off" barrier driven along the centerline of an armor stone revetment. This new structure is 10 feet wide at elevation 17.0 ft. N.G.V.D. with a seaward slope of 1 on 3 down to the original ground surface with a 10 foot toe. The landside of the revetment is sloped 1 on 2 down to existing ground surface. The section is comprised of a 6 foot thick layer of armor stone on 3 feet of under layer stone. This is placed on 1.5 feet of bedding stone on top of 1.5 feet of gravel.

The section from sta. 29+95 to sta. 32+00 is shown on Plate C-6 and is similar to the section for sta. 27+25 to sta. 29+25, except that the sheet piling is driven along the face of the existing stone wall revetment. The top of this berm is also at elevation 17.0 ft. NGVD.

The reach from sta. 32+00 to sta. 38+45, shown on Plate C-7 has a steel sheet pile wall and rock berm set 15 feet on the ocean side of the existing stone revetment. This new revetment is 10 feet wide at top elevation 17.0 ft. N.G.V.D. The armor and underlayer stone, bedding stone and gravel layers are similar to sta. 27+25 to sta. 29+95.

The section from sta. 38+45 to sta. 56+25 is shown on PLate C-7 consists of armor stone protection in front of the vertical face of the existing concrete wall. This rock berm will be 5 feet wide at top elevation 14.0 ft. N.G.V.D. with a seaward slope of 1 on 3 to the existing ground surface and a 10 foot toe. This armor stone will be 6 foot thick placed over a 3 foot layer of underlayer stone on top of a 1.5 foot layer of bedding stone and 1.5 feet of gravel.

The last section, sta. 56+25 to sta. 60+00 of the shore protection is shown on Plate C-7 consists of an armor stone berm 5 feet wide at top elevation 14.0 ft. N.G.V.D. placed in front of the existing concrete retaining wall. This armor stone will have a seaward slope of 1 on 3, and a 10 foot toe of the original ground surface. Under the 6-foot-thick armor stone will be a 3-foot layer of underlayer stone covering 1.5 feet of bedding stone and 1.5 feet of gravel.

3. Concrete Cap

Between sta. 19+20 and sta. 27+25 a concrete cap 1.7 feet high will be added to the existing concrete wall to bring the top of the wall elevation to 17.0 ft. N.G.V.D. - contiguous with the rest of the protective system.

Two rows of holes, 3' on centers will be drilled into the existing wall. Number 6 reinforcing steel bars will be grouted into these holes to anchor the concrete cap.

4. Backwater Protection

An earth berm, one foot high and 200 feet long with a top elevation of 11.0 ft. NGVD would be constructed on the existing median strip between Bennington Street and State Road. The berm would start at high ground on the Revere Beach Parkway bridge embankment and terminate at the intersection of Bennington and State Road. Provisions for extending the protective alinement about 50 feet into the intersection to reach high ground would include sufficient sandbags to obtain a height of about 8 inches. High ground is reached at the middle of the intersection, opposite the west end of Endicott Avenue. The earth berm would be seeded and constructed of compacted impervious fill with topsoil in the top six inches. The existing parkway embankment and road embankment from the north end of the proposed berm to the Eliot Circle seawall, about 1150 feet is also a project feature needed to prevent backwater flooding into Roughans. The berm is shown in Section on Plate C-6.

5. Interior Drainage

Interior drainage provisions include the existing pumping station with an improved intake structure and a new gravity drain. A sluice gate will be provided on existing drainage pipes which discharge into Sales Creek. During intense runoff conditions, drainage could be both to Sales Creek and through the existing Broad Sound Avenue pumping station. The Sales Creek sluice gate could be closed to prevent higher water in Sales Creek from entering the project area. The new 48 inch (concrete pipe) gravity drain at the pumping station will pass through the existing Reach E seawall and the proposed rock revetment, outleting at the toe of the structure. The gravity drain will have a positive closure sluice gate landside of the seawall.

These measures are shown on Plate C-4.

6. Pumping Station

The existing Broad Sound Avenue pumping station is located landside of the shore protection line along Reach E. Three pumps (2@ 15 MGD & 1 @ 1 MGD) with a design total capacity of 48 cfs, along with diesel powered generators, are the main features of the facility. Access to the station is from Broad Sound Avenue. Discharge to the ocean is through 30 inch and 4 inch cast iron discharge pipes. During storm tides the gate on the new gravity drain will be closed and the drainage pumped to the ocean.

D. OTHER PLANS INVESTIGATED

Other plans studied in Stage 2 consisted of the following:

One Plan offered protection against flooding resulting from three still water tide levels by stabilizing the existing facilities with a 1 on 4 rock berm and raising their heights respectively. The plan also called for a backwater cut-off wall and interior drainage improvements. This alternative was dropped because of the comparible level of protection offered by the structural plan described previously, with less impact on the study area.

Another consisted of the stabilization of existing facilities with a rock berm sloping 1 on 3 seaward at top elevation 14.0 feet N.G.V.D., with the addition of an offshore breakwater. Interior drainage improvements without additional pumping were also included in this plsn. Backwater protection complimented these structural measures also. This plan was eliminated due to its prohibitive costs.

See the Main Report for other alternatives investigated.

E. CONSTRUCTION PROCEDURES

To construct the revetment, an easement will be required on the landside of the existing wall or dike. From sta. 19+25 to sta. 27+25 this easement is on MDC property from sta. 27+25 to sta. 56+00. This working zone is in an open area and away from local highway interference. The 400 foot section of revetment from sta. 56+00 to sta. 60+00 runs along Winthrop Parkway and will require some type of traffic control. Construction of the revetment will start at sta. 60+00 and proceed in a northerly direction. Plscing at the underlayer and Armor Stone will be accomplished by working off a working surface on the oceanside of the wall.

At the two road net sites, raising at the grades and installation of the I-walls will require some detouring of the traffic but no real inconvenience to the local community is expected.

F. CONSTRUCTION MATERIALS

Anticipated construction materials will be grsvel for fill materials and rock for slope protection. Gravel can be obtained from commercial suppliers within a 30-mile radius of the study area. Rock can be obtained from commercial suppliers within a 40-mile radius of the study area.

G. ENVIRONMENTAL QUALITY ENHANCEMENT

At various locations along the revetment, steps will be set into the armor stone to provide access to the water and flats and also for use by sunbathers. These steps will be 20 feet long and will go from a top elevation of 17.5 ft. NGVD to existing ground surface. The sites are expected to be: near the southern end of Broad Sound Ave., Simpson's Pier, and Sta 30+00.

H. CONSTRUCTION FACILITIES

1. Contractor Facilities

The construction of the project will require a moderate size work force with varied construction skills, but largely in the heavy equipment and semiskilled trades. Within the greater Boston area, there is a sufficient number of workers who would commute to work and not require housing near the project. There would be a need for administration, mobilization and storage at the project site. Three locstions have been investigated, for such areas. These are at sta. 30+00, sta. 40+00, and sta. 42+00. Temporary facilities required by the contractor would be removed at the conclusion of work and the site(s) restored, or finished, as required.

2. Government Facilities

A field office would be required in the vicinity of the project. A winterized office trailer would be furnished as an ancillary obligation under the construction cost.

I. SCHEDULE OF CONSTRUCTION

Construction of the shore and backwater protection and interior drainage improvements will be accomplished under a single continuing contract to be awarded at the start of a construction year and will take two years to complete.

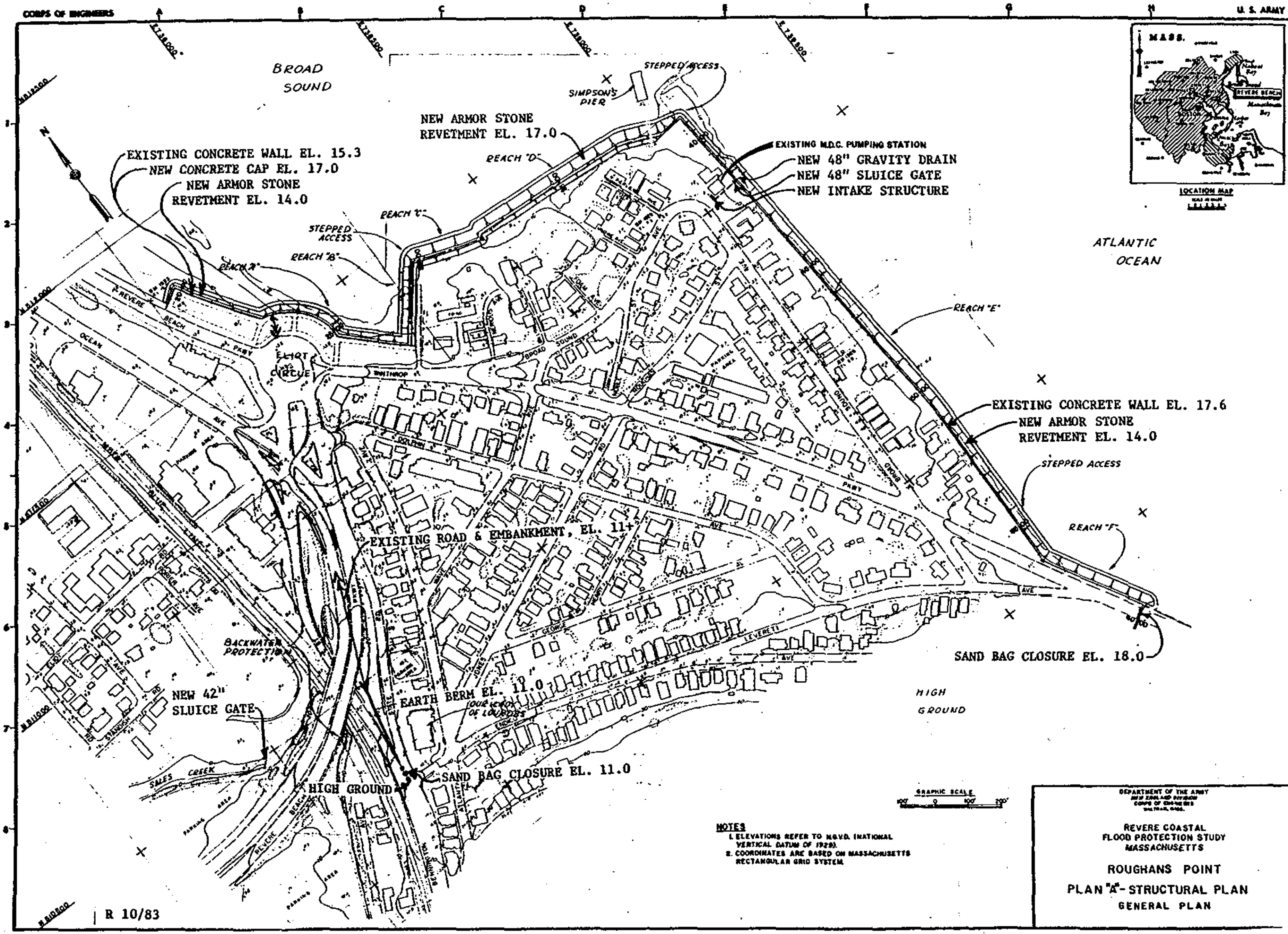
J. ESTIMATE OF COST

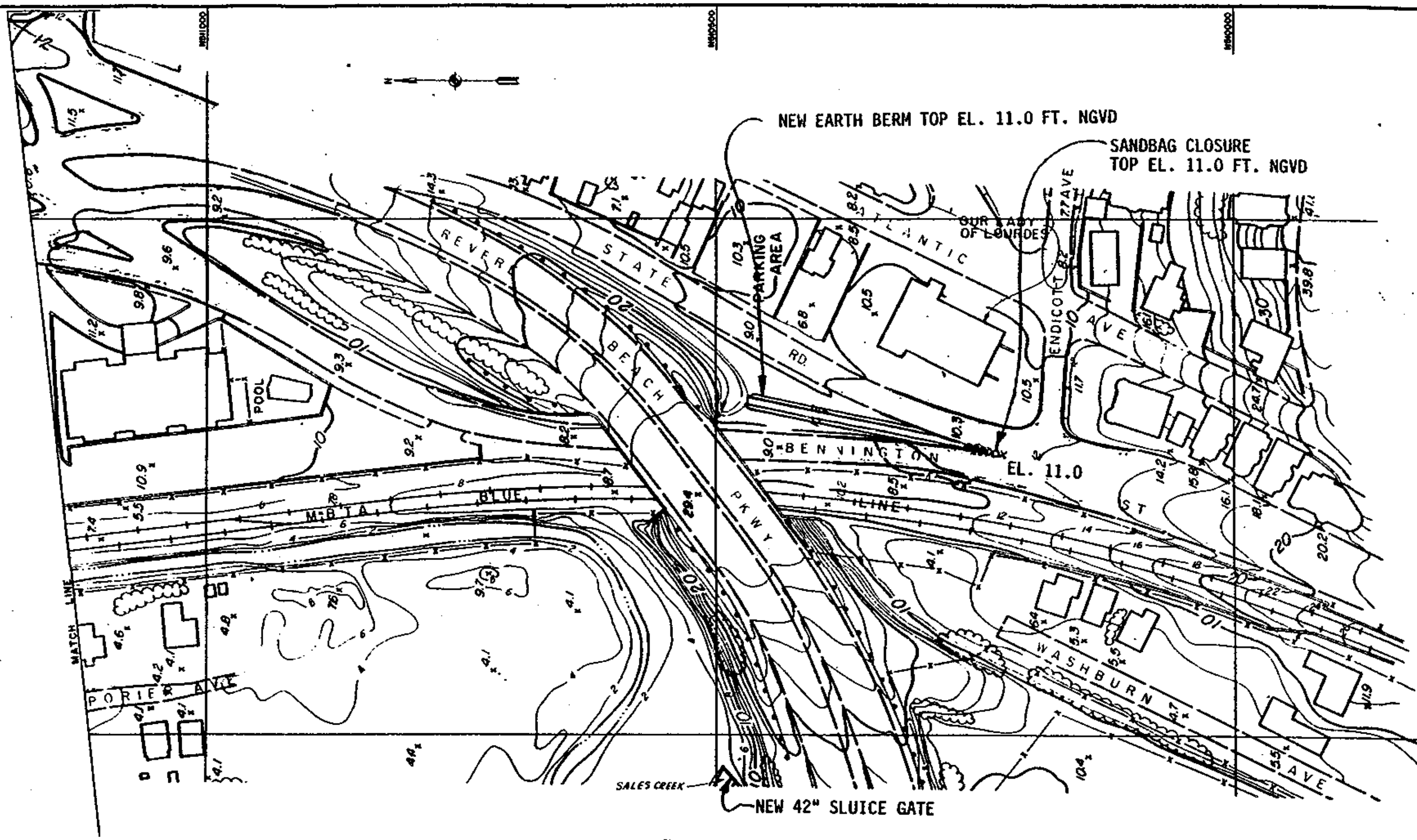
ESTIMATE OF COST
COASTAL PROTECTION
(FEBRUARY 1982 PRICE LEVELS)

	Description	Quantity	Unit	Unit Price	Amount
08.	BACKWATER EL. 11 PROTECTION				
	Preparation of Site	1	Job	L.S.	$5,000
	Compacted Impervious Fill	150	C.Y.	8.00	1,200
	Excavation General	80	C.Y.	5.00	400
	Topsoil	50	C.Y.	12.00	600
	Seeding	700	S.Y.	1.00	700
	Sand Bag Closure	50	L.F.	2.00	100
	Sub-Total - 08. BACKWATER PROTECTION				$8,000
	Contingencies (25%)				$2,000
	TOTAL - 08. BACKWATER PROTECTION				$10,000
10.	SHORE PROTECTION, EL. 17.0, 1:3 slope				
	Preparation at Site	1	Job	L.S.	$ 2,000
	Excavation General	50,000	C.Y.	5.00	250,000
	Armor Stone	59,000	C.Y.	35.00	2,065,000
	Underlayer Stone	27,000	C.Y.	30.00	810,000
	Bedding Stone	14,300	C.Y.	20.00	286,000
	Gravel Bedding	15,500	C.Y.	10.00	155,000
	Gravel Fill	6,000	C.Y.	10.00	60,000
	Random Fill	1,000	C.Y.	3.00	3,000
	Compacted Pervious Fill	4,200	C.Y.	8.00	33,600
	Steel Sheet Piling	26,000	S.F.	23.00	598,000
	Steel Dowels	1,600	lb.	1.00	1,600
	Concrete	100	C.Y.	200.00	20,000
	Access Steps	1	Job	L.S.	55,800
	Dowell Insertion, Drilling	1	Job	L.S.	15,000
	Sub-Total -10. SHORE PROTECTION				$4,355,000
	Contingencies (25%)				1,089,000
	TOTAL -10. SHORE PROTECTION				$5,444,000

Description	Quantity	Unit	Unit Price	Amount
13. INTERIOR DRAINAGE				
Preparation of Site	1	Job	L.S.	$ 400
Improvements to Existing Pump Sta.	1	Job	L.S.	260,000
Sales Creek Sluice Gate	1	Job	L.S.	30,000
Sub-Total -13. INTERIOR DRAINAGE				$290,400
Contingencies (25%)				$ 72,600
TOTAL -13. INTERIOR DRAINAGE				$363,000
TOTAL ESTIMATED CONSTRUCTION COST				$5,817,000*

*Lands and Damages, Engineering and Design, Supervision and Administration costs not included.


CORPS OF ENGINEERS
U. S. ARMY
BROAD SOUND
ATLANTIC OCEAN
SIMPSON'S PIER
STEPPED ACCESS
NEW ARMOR STONE REVETMENT EL. 17.0
REACH "D"
REACH "C"
REACH "B"
REACH "A"
REACH "E"
REACH "F"
EXISTING CONCRETE WALL EL. 15.3
NEW CONCRETE CAP EL. 17.0
NEW ARMOR STONE REVETMENT EL. 14.0
EXISTING M.D.C. PUMPING STATION
NEW 48" GRAVITY DRAIN
NEW 48" SLUICE GATE
NEW INTAKE STRUCTURE
ELIOT CIRCLE
EXISTING CONCRETE WALL EL. 17.6
NEW ARMOR STONE REVETMENT EL. 14.0
EXISTING ROAD & EMBANKMENT, EL. 11+
BACKWATER PROTECTION
NEW 42" SLUICE GATE
EARTH BERM EL. 11.0
SAND BAG CLOSURE EL. 18.0
HIGH GROUND
SAND BAG CLOSURE EL. 11.0
HIGH GROUND
SALES CREEK
LOCATION MAP
GRAPHIC SCALE
NOTES
1. ELEVATIONS REFER TO N.G.V.D. (NATIONAL VERTICAL DATUM OF 1929).
2. COORDINATES ARE BASED ON MASSACHUSETTS RECTANGULAR GRID SYSTEM.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
REVERE COASTAL FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHANS POINT
PLAN "A"- STRUCTURAL PLAN
GENERAL PLAN
R 10/83



BACKWATER PROTECTION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS

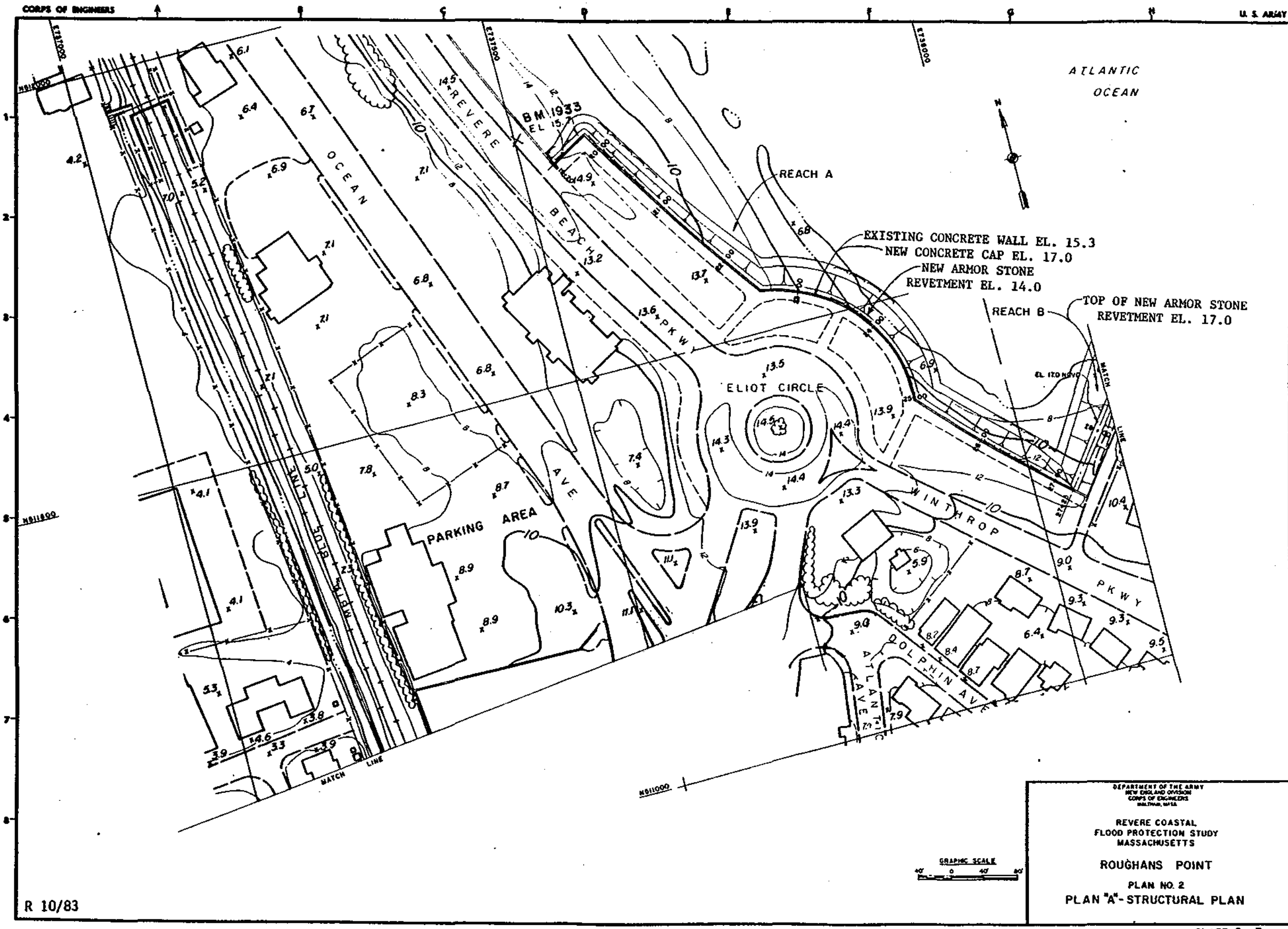
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS

ROUGHANS POINT

PLAN NO. 1

PLAN "A"- STRUCTURAL PLAN

R 10/83



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NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS

ROUGHANS POINT

PLAN NO. 2

PLAN "A"- STRUCTURAL PLAN

PLATE C-3

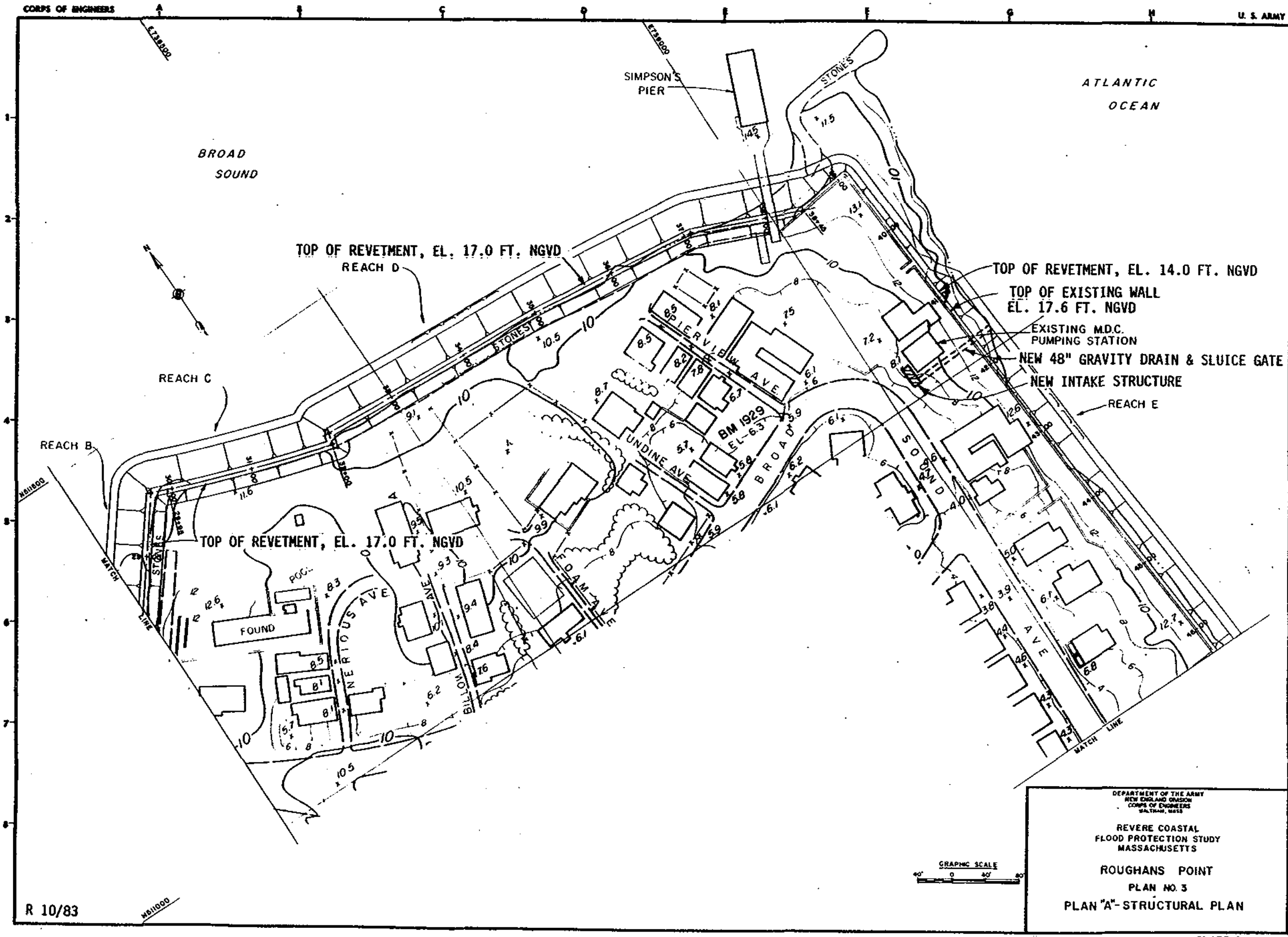

CORPS OF ENGINEERS
U. S. ARMY
ATLANTIC OCEAN
BROAD SOUND
SIMPSON'S PIER
STONES
TOP OF REVETMENT, EL. 17.0 FT. NGVD
REACH D
REACH C
REACH B
TOP OF REVETMENT, EL. 14.0 FT. NGVD
TOP OF EXISTING WALL EL. 17.6 FT. NGVD
EXISTING M.D.C. PUMPING STATION
NEW 48" GRAVITY DRAIN & SLUICE GATE
NEW INTAKE STRUCTURE
REACH E
TOP OF REVETMENT, EL. 17.0 FT. NGVD
PIERVIEW AVE
UNDINE AVE
BM 1929 EL-6.3
BROAD SOUND AVE
EDAM AVE
BILLOW AVE
NERIOUS AVE
FOUND
POOL
MATCH LINE
MATCH LINE
GRAPHIC SCALE
40' 0 40' 80'
R 10/83
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHANS POINT
PLAN NO. 3
PLAN "A"- STRUCTURAL PLAN

PLATE C-4

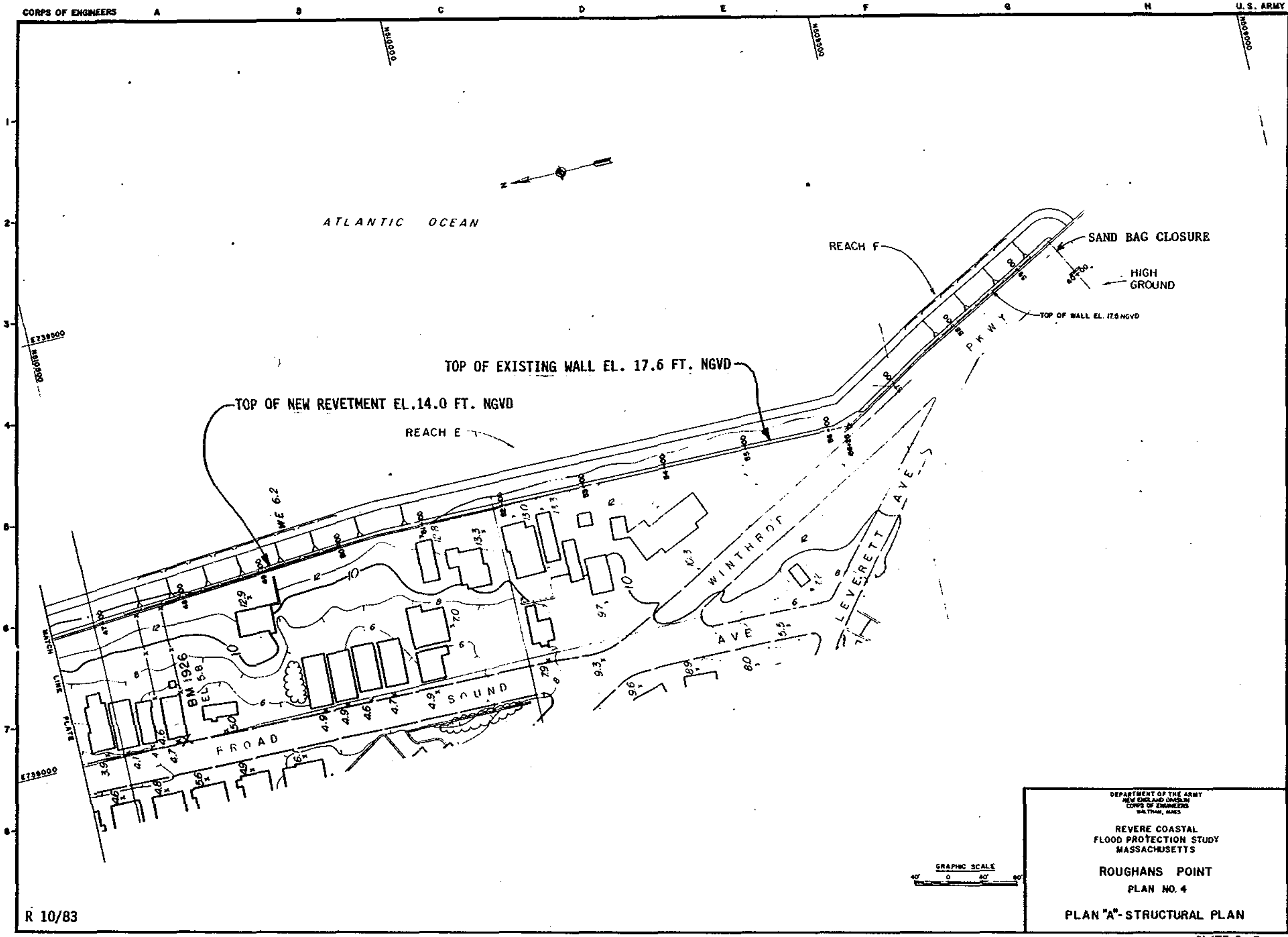
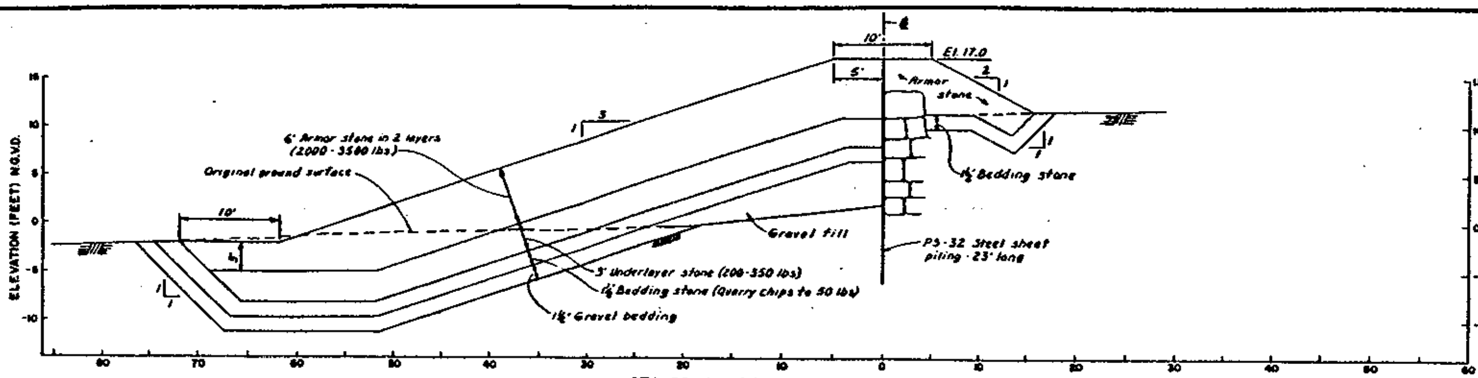
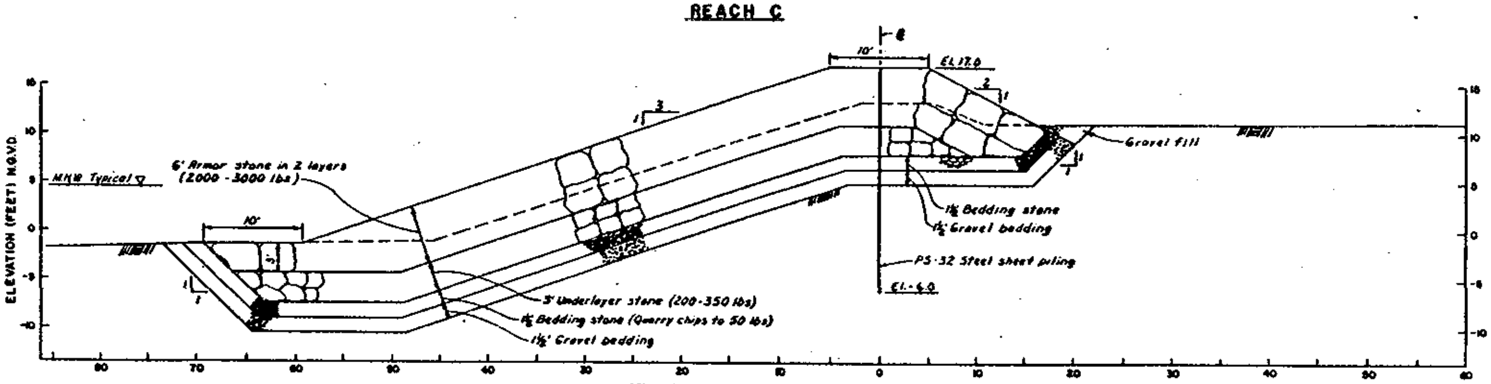

CORPS OF ENGINEERS
U.S. ARMY
ATLANTIC OCEAN
REACH F
SAND BAG CLOSURE
HIGH GROUND
TOP OF WALL EL. 17.6 NGVD
TOP OF EXISTING WALL EL. 17.6 FT. NGVD
TOP OF NEW REVETMENT EL.14.0 FT. NGVD
REACH E
WINTHROP PKWY
LEVERETT AVE
AVE
SOUND ROAD
BM 1926 EL 5.8
MATCH LINE PLATE
GRAPHIC SCALE
R 10/83
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHANS POINT
PLAN NO. 4
PLAN "A"- STRUCTURAL PLAN

PLATE C-5



STA 29+95-STA 32+00

REACH C



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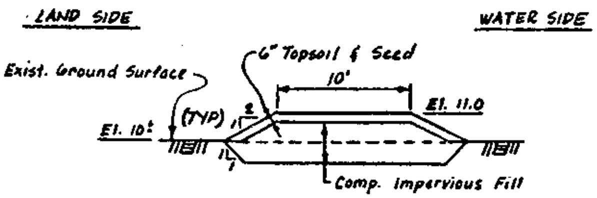
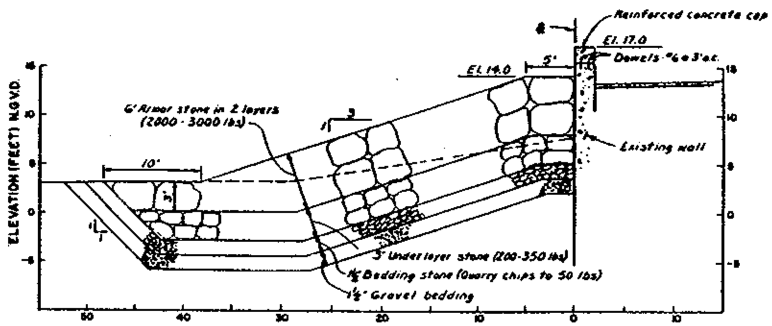


BACKWATER PROTECTION

EARTH BERM



STA 19+20-STA 27+25

REACH A

TYPICAL SECTIONS

R 10/83

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS

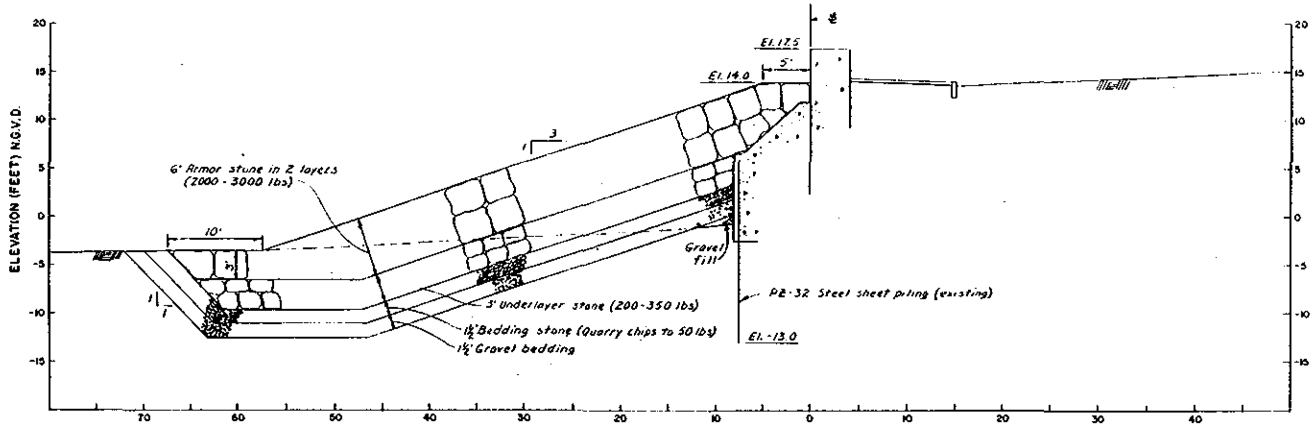
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS

ROUGHANS POINT

SECTIONS NO. 1

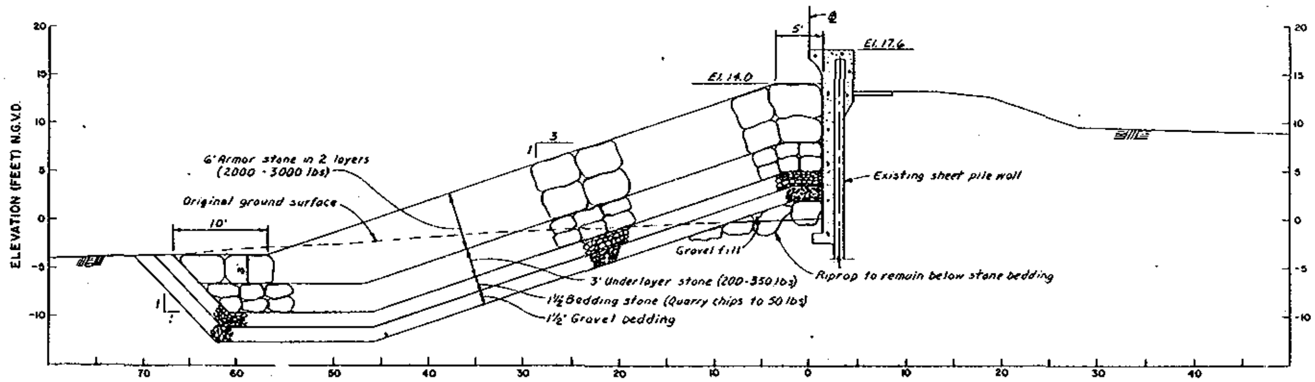
PLAN "A" - STRUCTURAL PLAN

GRAPHIC SCALE



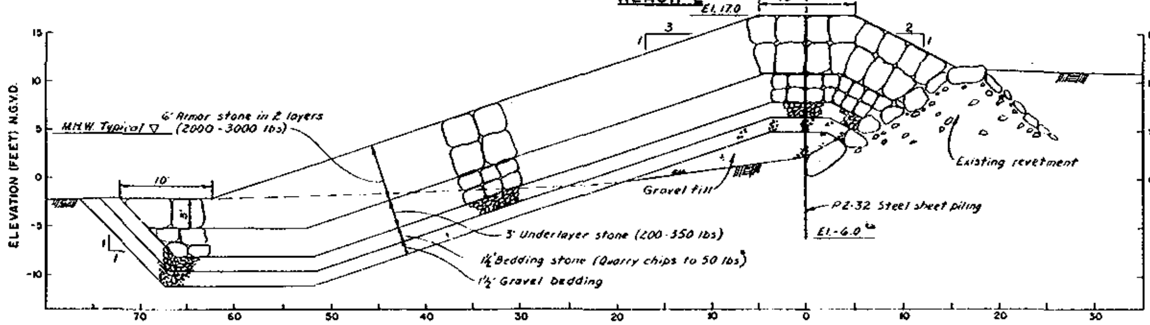
STA 56+25-STA 60+00

REACH F



STA 38+45-STA 56+25

REACH E



STA 32+00-STA 38+45

REACH D

TYPICAL SECTIONS

GRAPHIC SCALE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS

ROUGHANS POINT

SECTIONS NO. 2

PLAN "A"- STRUCTURAL PLAN

PLATE C-7

APPENDIX D

REAL ESTATE

APPENDIX D

REAL ESTATE

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF PLATES

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

424 TRAPELO ROAD

WALTHAM, MASSACHUSETTS

PRELIMINARY ESTIMATE OF REAL ESTATE COSTS

REVERE COASTAL FLOOD PROTECTION STUDY

ROUGHAN'S POINT

EASTERLY SIDE OF WINTHROP PARKWAY

REVERE, MASSACHUSETTS

JUNE 1981

PREPARED BY: Edward J. Fallon
EDWARD J. FALLON
Appraiser

REVIEWED BY: William D. Brown Jr.
WILLIAM D. BROWN, JR.
Review Appraiser

APPROVED BY: William R. Coke
WILLIAM R. COKE
Chief, Appraisal Branch

CERTIFICATION

This is to certify that I have personally inspected the lands described herein, that the facts and data used herein are, to the best of my knowledge and belief, true and correct, and that the appraisal values and costs represent my best and unbiased judgment of the Fair Market Value of the properties. I have no present nor intended future interest in the property.

Edward J. Fallon
EDWARD J. FALLON
Appraiser

June 14, 1981
DATE

PURPOSE

The purpose of this report is to estimate the Preliminary Real Estate Costs associated with Flood Protection at Roughan's Point, Revere, Massachusetts, as of June 1981.

INSPECTION OF THE REAL ESTATE

The properties easterly of Winthrop Parkway, within the Roughan's Point Area were viewed in the field during the month of May 1981.

LOCATION

The subject Roughan's Point study area is located in the Beachmont southeasterly section of Revere, Massachusetts.

PROJECT DESCRIPTION

This plan consists of total acquisition of all properties within the Roughan's Point easterly area.

The area commences at Eliott Circle and extends about 4300 feet south easterly along Winthrop Parkway ending at the intersection of Leverett Avenue, and Winthrop Parkway. Winthrop Parkway is the westerly boundary of the study area. The easterly boundary ends at the coastline of the Atlantic Ocean.

DESCRIPTION OF CITY AND PROJECT AREA

The City of Revere is located on the Massachusetts coast about two miles northeast of the City of Boston. About one-fifth of the area is a salt marsh adjacent to the Pines River Estuary, and about one-third of the city, including the marsh area, is below elevation 10 feet, mean sea level. The remainder of the city is gently rolling with a few steep hills, the highest elevation being at the reservoir on Fenno's Hill at about 192 feet above mean sea level. Most of the land above 10 feet mean sea level is fully developed and, for all practical purposes, any new development could be expected only at the expense of existing uses. The population of the city is about 43,000, and on peak summer days more than 20,000 people visit the 3½ miles long Revere Beach for recreational purposes.

PROJECT AREA

Roughan's Point. This low lying ocean front area in the Beachmont section of Revere consists mainly of permanent year round residences with a few summer residences in a thirty-three acre watershed. This acreage is subject to flooding usually on a yearly basis. Existing protection consists of a concrete seawall along the easterly shore having a top elevation of about 17 feet above mean sea level. The northerly facing shoreline is only protected by a stone dike having a top elevation of about 12 feet above mean sea level. The area is subjected to flooding from wave overtopping, without adequate pumping facilities.

SOIL

The soil of Roughan's Point is mainly white beach sand with a peat base.

MINERALS

There are no known mineral deposits having a commercial value within the project area.

EASEMENTS

There is a 50 foot wide permanent easement, consisting of 25 feet on either side of center line of the original concrete seawall that was constructed in 1936. The Massachusetts Division of Waterways acquired the necessary easement, for the construction, repair and maintenance of the sea wall. The seawall is 1700± feet long and is located along the shore, easterly of Broad Sound Avenue.

Portions of some of the structures are situated within the easement area along the westerly side of the seawall.

IMPROVEMENTS

Improvements within the study area are very diversified and consist of dwellings that are small seasonal cottages, converted cottages for year round living, one and two family dwellings that are old, new and remodeled. There is also a section of townhouses and condominiums.

The businesses in the area consist of a beauty parlor, located in a house, and a marina (Simpson's Pier) consisting of a wooden pier and a 3,000 square foot wood frame workshop/office building in need of repair.

Most of the improvements are stick-built with some being constructed of concrete block and brick.

ZONING

Zoning within the study area is primarily general residence with one area designated as general commercial.

The requirements for each type of zoning is as follows:

General Residence Zone

Single Family

Lot size: 8,000 Frontage: 80 feet; the structure may cover only 25% of the lot.

Two Family

Lot size: 10,000 Frontage: 100 feet; the structure may cover only 30% of the lot.

Row House & Apartment House

50% of the area.

Commercial Zone

80% of a corner lot; 70% of any other type of lot.

HIGHEST AND BEST USE

The highest and best use of the lands located within the study area, are those of their present use.

UTILITIES

Electric power, telephone facilities, sewage and water are available in the study area.

TIMBER

There is no marketable timber or for that matter, any timber within the study area.

AGRICULTURE

There are no agricultural areas within the study area.

CEMETERIES

There are no known cemeteries within the study area.

SEVERANCE DAMAGES

Severance damages usually occur when partial takings are acquired which restrict the remaining portion from full economic development. The severance damages are measured and estimated on the basis of "before" and "after" appraisal methods and will reflect actual value loss incurred to the remainder as a result of partial acquisition. Detail appraisals will reflect any possible losses. Preliminary investigations indicate that there is no severance damages as all properties will be acquired in there entirety within the proposed project area.

PROTECTION AND ENHANCEMENT OF CULTURAL ENVIRONMENT

In accordance with instructions set forth in teletype DA (DAEN) R 191306A, dated October 1971, Subject: "EO11593, 13 May 1971, Protection and Enhancement of Cultural Environment"; a study has been made in the subject areas. The study revealed that no local, State, Federally owned nor Federally-controlled property of historical significance would fall within the provisions of EO 11593.

CONTINGENCIES

A contingency allowance of 20 percent is considered to be reasonably adequate to provide for possible appreciation of property values from the time of this estimate to acquisition date, for possible minor property line adjustments or for additional hidden ownerships which may be developed by refinement to taking lines, for adverse condemnation awards and to allow for practical and realistic negotiations.

GOVERNMENT-OWNED FACILITIES

Section III of the Act of Congress approved 8 July 1958, (PL 85-500) authorized the protection, realteration, reconstruction, relocation or replacement of municipally-owned facilities. A preliminary inspection the property area indicated no Government-owned facilities are affected outside of a pumping station owned by the Metropolitan District Commission (MDC). Further studies will be conducted concerning the retention, protection and possible relocation of the facility, under Stage III Development.

TAX LOSS

The anticipated tax loss for this segment of Roughan's Point based upon the 1981 tax rate of $270.00 per thousand at a ratio of 21% is estimated to be about $410,000.

ACQUISITION COSTS

Acquisition costs will include costs for mapping, surveying, legal descriptions, title evidence, appraisals, negotiations, closing and administrative costs for possible condemnations. The acquisition costs are based upon this office's experience in similar civil works projects in this general area and are estimated at $3,000 per ownership. About 139 ownerships will be affected of which 41 are condominium and/or apartment ownerships.

RELOCATIONS ASSISTANCE COSTS

Public Law 91-646, Uniform Relocations Assistance Act of 1979, provided for uniform and equitable treatment of persons displaced from their homes, businesses or farms by a Federally Assisted Program. It also establishes uniform and equitable land acquisition policies for these projects. Included among the items under PL 91-646 are the following:

a. Moving Expenses
b. Replacement Housing (Homeowners)
c. Replacement Housing (Tenants)
d. Relocation Advisory Services
e. Recording Fees
f. Transfer Taxes
g. Mortgage Prepayment Costs
h. Real Estate Tax Refunds (Pro-rata)

Within a reasonable time prior to displacement, the taking authority must certify that there will be available, in areas generally not less desirable and at rents and prices within the financial means of the families and individuals displaced, decent, safe, and sanitary dwellings, equal in number to the number of, and available to, such displaced persons who require such dwellings and reasonable accessible to their places of employment.

There are ownerships in the area to be acquired in fee where the people will have to be relocated. Therefore, the following estimates are included for planning purposes to cover the implementation of this act.

Fee Acquisition

119 Private ownerships	@	$15,000		$ 1,785,000
18 Tenants	@	4,000		72,000
1 Public ownership	@	Nominal		
1 Commercial marina	@	2,000		2,000
			TOTAL	$ 1,859,000

EVALUATION

The values of lands and improvements within the project area have been estimated by use of the market data or comparable sales approach. This approach to value involves a comparison between the property being appraised and recent sales transactions of similar properties in the vicinity of the property being appraised.

A search was made in the general area to obtain market data for use in estimating the value of the required lands and improvements. Local officials, real estate brokers, appraisers and other knowledgeable persons were contacted to secure data and value estimates.

The estimated values of lands and improvements, as presented are based on a study and analysis of numerous sales and other data gathered during this investigation. The sales used are all located within and in proximity to the study area.

Sales in the study area itself, since the Blizzard of 1978, have been relatively rare due to the amount of destruction that was encured by the Blizzard. Immediately after the blizzard and into the early part of 1980, sales of property were far below the market value because the threat of the blizzard was still remembered. However, since that time, buildings have been raised up at least one story and a foundation added. Repairs, flood proofing and remodeling have been completed on a large amount of dwellings in the area while others are still in the process.

Another factor affecting the sales in the area is that the average owner either lives or owns that property for an average of 18 years. Based upon recent sociological studies conducted by the Corps of Engineers.

SUMMARY OF REAL ESTATE COSTS

There follows an estimate of the Real Estate Costs for the proposed acquisition of Roughan's Point Easterly.

Land & Improvements	$ 7,233,000		
Contingencies 20% of above	1,447,000		
Sub Total			$ 8,680,000
Acquisition Costs			417,000
Relocation Assistance Costs			1,859,000
Severance Damages			0
Total Estimated Real Estate Costs			$10,956,000
		Call	$11,000,000

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

SUPPLEMENTAL REPORT I
REVISED-PRELIMINARY ESTIMATE OF REAL ESTATE COSTS
REVERE COASTAL FLOOD PROTECTION STUDY
ROUGHANS POINT

STRUCTURAL PLAN

ROCK REVETMENT, CUT-OFF WALL AND PUMPING STATION
AT ELEVATION 17.0 FEET NGVD
REVERE, MASSACHUSETTS

OCTOBER 1983

Prepared By: Edward J. Fallon
EDWARD J. FALLON
Appraiser

Reviewed &
Approved By: William D. Brown, Jr.
WILLIAM D. BROWN, JR.
Chief, Appraisal Branch

PURPOSE

The purpose of this Supplemental Report (I) is to estimate the preliminary real estate costs associated with the structural plan for flood protection at Roughans Point, Revere, Massachusetts, as of February 1982.

LOCATION AND INSPECTION OF THE REAL ESTATE

The subject Roughans Point and associated study areas are located in the Beachmont southeasterly section of Revere, Massachusetts. These areas were viewed in the field during the month of February 1982.

PROJECT DESCRIPTION

The structural plan consists of acquiring permanent easement interests for the construction of a steel sheet piling as a "cut-off" barrier driven along the centerline of a rock revetment in Reaches B, C, and D. This structure is 10 feet wide at elevation 17.0/17.5 feet N.G. V. D., with a seaward slope of 1 on 3 down to original ground surface with a 10 foot toe, while the land side of the revetment is sloped 1 on 2 down to existing ground surface.

Other areas will be necessary for construction of a concrete "I" wall in the backwater protection areas and an area for construction of a 50 cfs pumping station and temporary staging areas.

WALLS

Reaches A, B, C, D, E, and F are located along the Atlantic Ocean to the east of the Revere Beach Boulevard and Winthrop Parkway in the Beachmont, Roughans Point section of Revere, Massachusetts.

Reach "A" commences at the northerly end of the existing MDC wall at Eliot Circle and runs a distance of about 822 feet to the southeast where it ties into Reach "B". Reach "A's" vertical height would be increased to elevation 17.0/17.5 feet NGVD by adding 1.7/2.2 feet of reinforced concrete to the existing wall.

Reach "B" commences about 75 feet easterly of Winthrop Parkway along a right-of-way road. This reach traverses for about 250 feet where it then ties into Reach "C", which traverses in an easterly direction for about 225 feet where it then becomes Reach "D" and still continues in an easterly direction for about 615 feet where it ties into Reach "E" at the entrance to Simpson's Pier. Reach "E" traverses in a southerly direction for about 1700 feet where it then ties into Reach "F", which traverses in a south-easterly direction a distance of about 380 feet ending at the wall which runs along Winthrop Parkway.

The backwater protection is by means of an I-wall, which commences in the southeasterly embankment of the Revere Beach Parkway, that lies between Bennington Street and State Road, and runs in a southerly direction for about 215 feet where it will tie into a newly raised section of road.

Another I-wall lies within the median divider of the Revere Beach Parkway. This reach commences northwesterly of State Road running in a northeasterly direction for about 115 feet then turning slightly and running in a due north direction towards Ocean Avenue for about 115 feet.

PUMPING STATION

A building site is necessary for the construction of a 50 cfs pumping station and associated out fall. This parcel fronts on Broad Sound Avenue and Pebble Street and contains about 14,400 square feet with about 7,200 square feet considered as buildable. The remaining 7,200 square feet is for a beach area with riparian rights. The property is encumbered by a permanent easement (concrete seawall) with the Massachusetts Division of waterways.

The construction of the walls and pumping stations for flood protection in this section of Revere will affect about 11 private ownerships and 3 public ownerships for a total of 14 total ownerships.

IMPROVEMENTS

There are no known improvements that would be affected by the project.

TAX LOSS

The anticipated tax loss for this segment of the flood protection study for Roughans Point based upon the 1981 tax rate of $270.00 per thousand at a ratio of 21% is estimated to be $2,400.

ACQUISITION COSTS

Acqusition costs will include costs for mapping, surveying, legal descriptions, title evidence, appraisals, negotiations, closing and administrative costs for possible condemnations. The acqusition costs are based upon this office's experience in similar civil works projects in the general area and are estimated at $3,000 per ownership. About 14 ownerships will be affected.

RELOCATION ASSISTANCE COSTS

Public Law 91-646, Uniform Relocations Assistance Act of 1970, provided for uniform and equitable treatment of persons displaced from their homes, businesses, or farms by a Federally Assisted Program. It also establishes uniform and equitable land acquisition polices for these projects. Included among the items under PL 91-646 are the following:

a. Moving Expenses
b. Replacement Housing (Homeowners)
c. Replacmenet Housing (Tenants)

d. Relocation Advisory Services
e. Recording Fees
f. Transfer Taxes
g. Mortgage Prepayment Costs
h. Real Estate Tax Refunds (Pro-rata)

Within a reasonable time prior to displacement, the taking authority must certify that there will be available, in areas generally not less desirable and at rents and prices within the financial means of the families and individuals displaced, decent, safe and sanitary dwellings, equal in number to the number of, and available to, such displaced persons who require such dwellings and reasonably accessible to their places of employment.

There is only one ownership in the area that is to be acquired in fee. There are also ten parcels affected by the permanent easement interests. Therefore, the following estimates are included for planning purposes to cover the implementation of this act.

Fee Acquisition	
1 Private Ownership @ $200	$ 200
Permanent Easements	
10 Private Ownerships @ $200	2,000
3 Public Ownerships Nominal	0
14 Total Private and Public Ownerships	$2,200

SEVERANCE DAMAGES

Severance damages usually occur when partial takings are acquired which restrict the remaining portion from full economic development. The severance damages are measured and estimated on the basis of "before" and "after" appraisal methods and will reflect actual value loss incurred to the remainder as a result of partial acquisiton. Detailed appraisals will reflect these losses. Preliminary investigations indicate that there may be some severance damages to some properties that are affected by the proposed project. For planning pruposes these costs if any are provided for in the contingency factor.

PROTECTION AND ENHANCEMENT OF CULTURAL ENVIRONMENT

In accordance with instructions set forth in teletype DA (DAEN) R 191306A, dated October 1971, Subject: "EO11593, 13 May 1971, Protection and Ehancement of Cultural Environment;" a study has been made in the subject areas. The study revealed that no local, State, Federally-owned nor Federally-controlled property of historical significance would fall within the provisins of EO11593.

CONTINGENCIES

A contingency allowance of 20 percent is considered to be reasonably adequate to provide for possible appreciation of property values from the time of this estimate to acquisition date, for possible minor property line adjustments or for additional hidden ownerships which may be developed by refinement to taking lines for adverse condemnation awards and to allow for practical and realistic negotiations.

GOVERNMENT-OWNED FACILITIES

Section III of the Act of Congress approved 8 July 1958, (PL 85-500) authorized the protection, realteration, reconstruction, relocation or replacement of municipally-owned facilities. A preliminary inspection of the property area indicated no Government-owned facilities are affected outside of municipally-owned land.

FEE REQUIREMENTS

Preliminary investigations indicate that only one unimproved home site would be acquired. The fee area which is necessary for the proposed construction of the 50 cfs pumping station has an estimated value of $43,000.

EASEMENT AREAS

Permanent Easement Areas

Permanent easements for construction and maintenance purposes in Reaches A, E, F, and the backwater protection areas are not necessary as these sections are presently encumbered under permanent easements by the MDC (Metropolitan District Commission) for a seawall in Reaches A, E, F, and Roadway (Revere Beach Parkway) in the backwater protection areas.

The easement is comprised of an area which is 65 feet wide, 25 feet seaward, and 40 feet landward from the centerline of the proposed wall in Reaches B, C, D, and contain about 1.63± acres of private lands.

The areas to be affected in Reaches B, C, and D are along the ocean shoreline in the rear yards of the affected properties. Preliminary investigations indicate that after the imposition of the permanent easement interest, the highest and best use of the remainders of the properties will not be materially affected. The cost to acquire the permanent easement areas would be equivalent to the underlying fee value since those uses would be for project purposes. However, lands would remain in their private ownerships to maintain conformity of their existing lot areas. The estimated costs for the easement rights are predicated on the assumption that construction methods will be of the excavation and pile driving methods that would not adversely affect surface or near surface improvements. If it is determined and found that selected methods of construction would cause damage to surface or near-surface improvements then the estimated costs for easement rights would not remain valid and a new in depth real estate study of the proposed taking would be required.

The following cost is predicated on an estimated market value of $6.00 per square foot in the residential area.

1.63 acres private land (residential use)
@ $6.00 per square foot = $425,100

TEMPORARY CONSTRUCTION EASEMENTS

Temporary construction easements required to complete the rock revetment in Reaches B, C and D contain about 3.10 acres.

Approximately 1.85 acres for a staging area are necessary of which about .82 acres are located at the end of Nerious Avenue and behind an old swimming tank and about .87 acres are located at the entrance to Simpson's Pier and .15 acres are located alongside the existing pumping station. Additional temporary construction easements 50 feet wide, containing about 1.25 acres, along the southerly side (shoreside) of the rock revetment are also required.

The land areas to be encumbered by temporary easements have an estimated market value of about $6.00 per square foot in the residential area. Predicated upon a fair return of invested capital, the use of the owner's land for about one year is estimated as follows:

1.85 acres private land @ $6.00 per square foot		$483,516
1.25 acres private land @ $6.00 per square foot		326,700
3.10 Total Acres	Total	$810,216
Fair Return @ 15% per year (for one year term)		$121,532
	Call	$122,000

CONCLUSIONS AND SUMMARY OF REAL ESTATE COSTS

The area of study for this segment of the Revere Beach Flood Protection Study at Roughans Point is based upon enginerring drawings supplied by the Engineering Division and assessors maps supplied by the city of Revere.

It is noted that Reaches A, E, F, and the backwater protection areas are presently encumbered with permanent easements for construction and maintenance purposes. Therefore, no additional costs will be required for these areas.

The alignment of the rock revetment and "I" cut off-walls and temporary easement areas are subject to refinement prior to proposed construction of this segment of the project.

The value of the lands and improvements within the project area have been estimated by use of the market data or sales comparison approach. A search was conducted in the general area to obtain market data. Local officials, real estate brokers, appraisers and other knowledgeable persons were interviewed to obtain data and value estimates.

SUMMARY OF REAL ESTATE COSTS

There follows an estimate of the real estate costs for the interests proposed for acquisition for the rock revetments and "I" walls for a one year period. Plate D-1 depicts the fee and easement areas needed for the proposed structural plan.

	With 50 cfs Pumping Station	Rounded to Closest $1,000
Land & Improvements		
Fee Acquisition	$ 43,000	
Permanent Easements	425,000	
Temporary Easements	122,000	
	$590,000	
Contingency - 20% of above	118,000	
Subtotal		$708,000
Acquisition Costs		42,000
Relocation Assistance Costs		2,200
TOTAL ESTIMATED REAL ESTATE COSTS		$752,200
CALL		$752,000

	Without 50 cfs Pumping Station	
Lands & Improvements		
Permanent Easements	$425,000	
Temporary Easemetns	122,000	
	$547,000	
Contingency - 20% of above	109,400	
Subtotal		$656,400
Acquisition Costs		39,000
Relocation Assistance Costs		2,000
TOTAL ESTIMATED REAL ESTATE COSTS		$697,400
CALL		$697,000

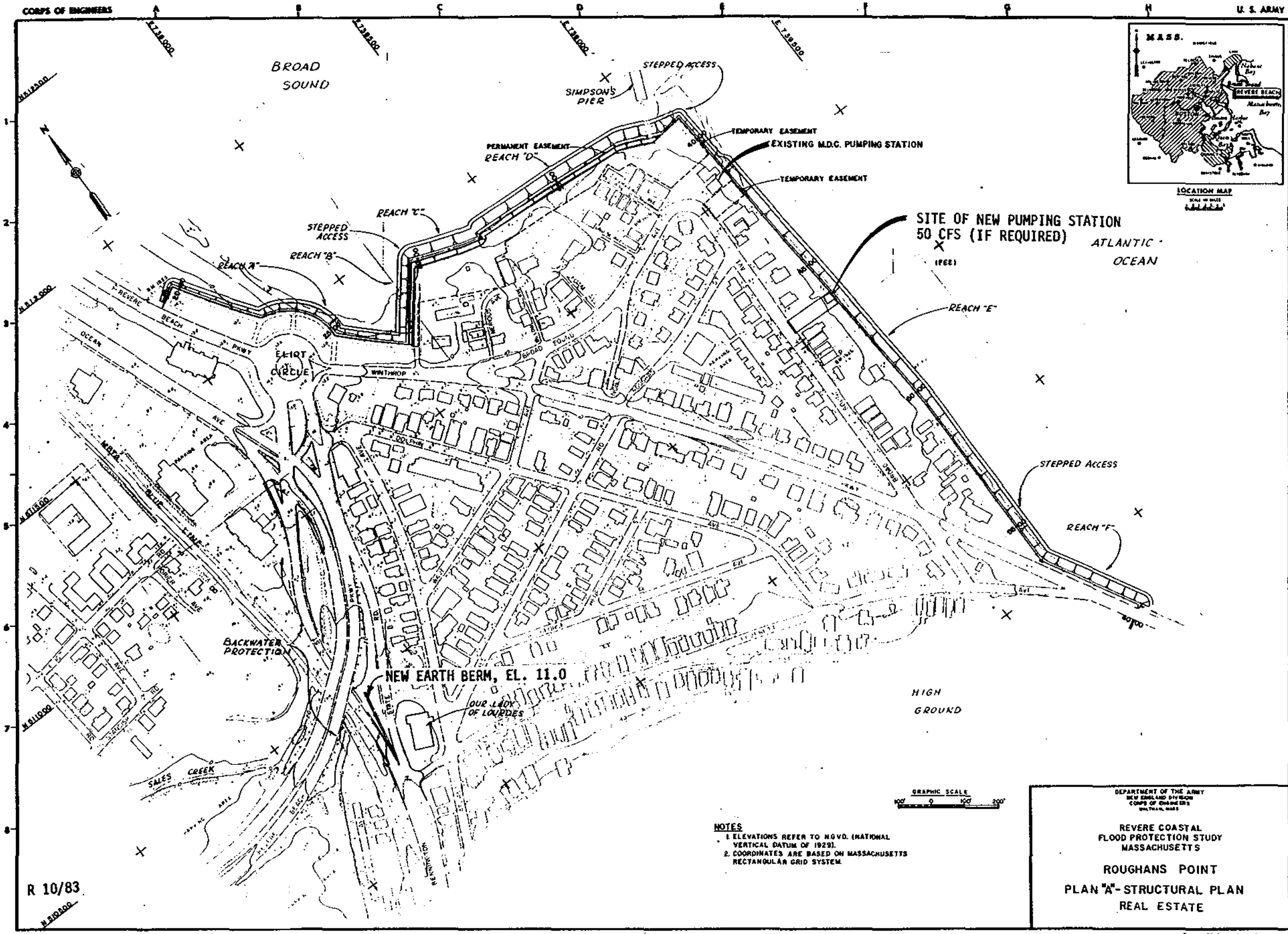

CORPS OF ENGINEERS
U. S. ARMY
BROAD SOUND
ATLANTIC OCEAN
SIMPSON'S PIER
STEPPED ACCESS
TEMPORARY EASEMENT
EXISTING M.D.C. PUMPING STATION
PERMANENT EASEMENT
REACH "D"
TEMPORARY EASEMENT
REACH "C"
STEPPED ACCESS
REACH "B"
REACH "A"
SITE OF NEW PUMPING STATION
50 CFS (IF REQUIRED)
(FEE)
REACH "E"
ELIOT CIRCLE
WINTHROP
STEPPED ACCESS
REACH "F"
BACKWATER PROTECTION
NEW EARTH BERM, EL. 11.0
OUR LADY OF LOURDES
HIGH GROUND
SALES CREEK
LOCATION MAP
MASS.
REVERE BEACH
GRAPHIC SCALE
100' 0 100' 200'
NOTES
1. ELEVATIONS REFER TO N.G.V.D. (NATIONAL VERTICAL DATUM OF 1929).
2. COORDINATES ARE BASED ON MASSACHUSETTS RECTANGULAR GRID SYSTEM.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS
REVERE COASTAL
FLOOD PROTECTION STUDY
MASSACHUSETTS
ROUGHANS POINT
PLAN "A"- STRUCTURAL PLAN
REAL ESTATE
R 10/83

PLATE D-1

APPENDIX E

ECONOMICS

APPENDIX E
ECONOMICS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF EXHIBITS

ROUGHANS POINT
ECONOMIC APPENDIX

METHODOLOGY

The economic justification of the proposed improvements was determined by comparing the average annual benefits accruing to the project over its economic lifespan to the average annual costs. In general, benefits should equal or exceed the costs for the Federal Government to participate in the project. Exceptions may be made in cases where subtantial non-quantifiable environmental quality benefits exist.

Benefits and costs are made comparable by conversion to an equivalent time basis using an interest rate of 8-1/8%. This rate, as specified in the Federal Register, is to be used by Federal agencies in the formulation and evaluation of water and related land resource plans for the period, October 1, 1983 through and including September 30, 1984. All costs and benefits are stated at the October 1983 price level. The project economic lifetime is considered to be 100 years.

The analysis of costs and benefits follows standard U.S. Army Corps of Engineer procedures. The value of all goods and services used in the project has been estimated during the process of developing cost data. Benefit categories investigated include flood damages prevented (existing and future), affluence benefits, flood insurance administration reduction, prevention of emergency costs, location, intensification, and employment benefits.

FIRST COSTS

The first cost of the selected structural alternative, plan A-5(4) is presented below. Included is a 25% contingency allowance. Also, engineering and design along with supervision and administration are estimated to be 25% of total construction cost. Costs for real estate and interest during construction are also included.

Structural First Cost - 17 Ft. Wall, 1:3 Slope, Berm at EL. 11

Construction First Cost	$5,095,000
Contingencies (25%)	1,274,000
Subtotal	$6,369,000
E & D, S & A (25%)	1,592,000
Subtotal	$7,961,000
Real Estate	$ 763,000
Interest During Construction	$ 716,000
TOTAL	$9,440,000

ANNUAL COSTS

Annual costs are determined by applying the capital recovery factor of .08128 for a 100-year project with a 8-1/8% interest rate. Anticipated operation and maintenance costs are also added as shown below.

PLAN A-5(4)
Structural Plan
Annual Cost - 17 Ft. Wall, 1:3 Slope, Berm at EL. 11

Annual Costs	$767,000
O, M & R	13,000
Total	$780,000

DAMAGE SURVEY

The first step undertaken as part of the economic analysis was a damage survey of Roughans Point conducted in 1978 and a more extensive sampling in the fall of 1980. Residental properties were divided into 20 categories as displayed in Exhibit 1. One to six structures from each category were surveyed and loss figures were averaged to arrive at a representative stage damage relationship for each category. Flood losses were referenced to the structures' first floor. Commercial/public buildings were handled individually. Highway and public utility losses were referenced to the record event.

The sources of information used to arrive at the final stage damage relationships included tax records, assessments, personal estimates and damage estimates by other knowledgeable individuals. References used in the evaluation of potential damages are listed in Exhibit 2. In addition to damage data the survey also obtained precise elevation data. For each home in the Roughans Point area, a residental structure description form was used to record the collected information. A sample form is displayed as Exhibit 3. Also, photographs were taken and used to determine the category for each structure. The result of the survey is the typical stage damage sheet displayed as Exhibit 4. The types of damages included in the survey and the range of potential damages are displayed in Exhibits 5 and 6, respectively.

The damage survey confirmed the unique nature of the Roughans Point area. Approximately 50% of the homes were originally intended for summer use. As the proximity of Revere to the Boston Metropolitan area became more attractive, these seasonal homes were winterized and expanded. Many are older homes that suffer from extreme settling. A number of houses have been floodproofed through a HUD financed floodproofing program.

During the process of conducting the survey several residents commented upon the flooding problem and recommended actions to help remedy the situation. It was reported that seawater overtops the existing project near the most southerly section of Roughans Point adjacent to 200 Winthrop Parkway. Recommended improvements include additional heating coils for storm inlet grates to prevent icing, screens for debris, rehabilitiation of the jetty, construction of an offshore breakwater and raising the seawalls. Additionally, it was noted that water ponds for a period of several days in the vicinity of Henry Street, George Street and Jones Road. A drain connecting the MDC pumping station was advised.

EXHIBIT I

CATEGORIES

1. Modern 2 Family 2 Story
2. Colonial 1 Family or 2 Family, 2-2-1/2 Story
3. Contemporary Tri-level 1 Family or 2 Family
4. Spilt Level 2 Family
5. Cottage 1 Family — NO BASEMENT
6. Summer Cottage 1 Family — NO BASEMENT
7. Summer Duplex Cottage 2 Family — NO BASEMENT
8. Duplex Garrison 2 Story 2 Family — NO BASEMENT
9. 3 Family Frame 3 Story Flat Roof
10. Cape (medium) 1-1/2 Story 1 Family
11. Ranch Modified to Garrison 1 Family
12. Ranch Modified to Colonial 1 Family
13. Bungelow (jacked)
14. Bungelow small 1 Family
15. Mobile (converted) 1 Family
16. Special Frame 2 Story 2 Family
17. Ranch (medium)
18. Ranch (small)
19. Ranch (large)
20. Raised Ranch 1 and 2 Family

Exhibit 2
References

1. Means Robert S. Building Construction Cost Data. Kingston, Mass., R. S. Means Co., Inc., Annually.

2. Richardson General Construction Estimating Mansonry Metals, Solana Beach, Cal., Richardson Eng. Serv. Inc., Annual.

3. McMahon Leonard A., Doge Guide to Public Works Heavy Construction and Building Construction. N.Y.C. McGraw-Hills Annual.

4. McMaster-Carr Cataloge. Chicago McMaster-Carr Supply Co., Annual.

5. Hilbok, Albert J., Building Costs, Berger Design Cost. File MBM Inc., Annual

6. MicKadeit, Robert E., Building Construction Mateirals & Types of Construction. N.Y. John Wiley & Sons 1975

7. Montgomery Ward Catelogue. Albany, N.Y., Montegomery Ward Co., Inc., Annually.

8. New England Real Estate Journal New England, R.E., Journal Accord, Mass., Weekly

9. Mass. R.E. Banking and Commercial Weekly. Banker Trademan. Warren Publishing Corp., Boston, Mass., Weekly

10. Sears Roebuck & Co. Annually

11. Brewsters. Prov., R.I., Quarterly

12. Professional experience including thirty years dealing with urban housing problems.

EXHIBIT 3

U.S. CORPS OF ENGINEERS - NEW ENGLAND

FLOOD PLAIN INFORMATION FORM
(Residence)

Visual Inspection Information

Occupant (if known):

Address: Jones Ave

City or Town: Revere

Type of Construction: Frame: (✓) Brick: ( ) Concrete: ( ) Other ( )
Type of Structure: Ranch: ( ) Split: ( ) Cape: ( ) Colonial: ( ) 2-Story (✓)
3-Story: ( ) Cottage: ( ) Camp: ( ) Duplex: ( )
Contemporary: ( ) Converted Mobile Home: ( ) Other: ( )

Families in Dwelling: 1: ( ) 2: (✓) 3: ( ) More: ( )
Number of Stories: 1: ( ) 1-1½: ( ) 2: (✓) 2-2½: ( ) 3: ( ) More: ( )

Basement: Yes: (✓) No: ( )
Type of Basement: Brick: ( ) Concrete: ( ) Stone: ( ) Concrete Block: (✓)
Jacked: ( )
Finished into Living space: None: (✓) ½: ( ) All: ( )
Garage: In structure: ( ) Attached: ( ) Separate ( ) None: (✓)
Spaces: 1: ( ) 2: ( ) 3: ( )
Floor: Ground level: ( ) Below ( )

	Good	Fair	Bad
Condition of Structure:	1: ( )	2: (✓)	3: ( )
Condition & Extent of landscaping:	1: ( )	2: (✓)	3: ( )
Condition of neighborhood	1: ( )	2: (✓)	3: ( )

Elevation of ground at foundation: msl 6.50
Height of first floor: 4.3 ft. (right front)
Height of first floor: 4.7 ft. (front entrance)
Height of first entry: 2.3 ft.

Other Comments:
No apparent floodproofing Colonial

From Town Assessor:
Owner's Name: [illegible]
Assessed Value: $ 4150 Date 1975
Area of Structure: ____ square feet
Area of Land: 3418 sq ft square feet

EXHIBIT 4

NEW ENGLAND DIVISION CORPS OF ENGINEERS
FLOOD LOSSES - [illegible]DENTIAL

Tri Lol

River or Stream/Tidal Atlantic

State Ma Side of River (R. or L. looking downstream)

Revere Village

Company or Owner

Address Point [illegible]

Source of Information Owner

1. DESCRIPTION [illegible] 5' deep [illegible] Sun Deck Tri Lol

No. of stories: ; Type Contemporary

Size Mat'l

Use Stud Hgt

Record Flood El Cellar 1st Floor

Height of 1st Floor above ground: Front 1½' Rear 3'4" 2nd lol

ASSESSMENT: LAND 24 BUILDING 40 LAND AREA 6,400 18,106 RECENT SALE 1990 Cost Mtls 75,000

Flood Date 1978 Recurring Loss in $1000 Units

				-8		-6		-4		-2		1st Fl	+1	+2	+3		REMARKS		
✓Bsmt. Struct. Cleanup & Other						0	0.2	0.3	1.3	2.0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	✓
×Util. - Heat, Elec, Plum, Gas, AC							0	0.2	0.5	0.3	1.0	1.0	1.5	3.0	4.0	6.0	6.0	6.0	×
–Contents - Furn, Tools, Sport Gds							0	1.0	2.5	4.0	6.5	7.2	7.2	7.2	7.2	7.2	7.2	7.2	–
Sub Total							0	2.2	4.3	6.8	11.3	12.0	12.5	14.0	15.0	17.0	17.0	17.0	
Outside - Grounds, Fence, Drive						0	0.5	1.0	1.5	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
✓1st Floor Struct. & above											0	1.5	4.0	6.0	8.0	10.0	14.0	16.0	✓
–Contents											0	1.0	2.0	5.0	8.0	8.0	8.0	8.0	–
+Car -/Gar.							0					5.2	5.2	5.2	5.2	5.2	5.2	5.2	–
TOTAL						0	0.5	3.2	5.7	8.8	13.7	17.2	26.2	32.7	38.7	42.7	46.7	48.7	
								1	2	3	7	7	14	14	21	28	36	42	
Added Cost of Food, room, Time-Necessities								0.1	0.2	0.3	0.7	0.7	1.4	1.4	2.1	2.8	3.6	4.2	
Other Cost																			
TOTAL NON-PHYSICAL						0	0	0.1	0.2	0.3	0.7	0.7	1.4	1.4	2.1	2.8	3.6	4.2	
TOTAL PHYSICAL & NON-PHYSICAL						0	0.5	3.3	5.9	9.1	14.4	17.9	27.6	34.1	40.8	45.5	50.3	52.9	

E-6

OTHER SIMILAR STRUCTURES

ADDRESS	DIFF.SIZE	DIFF ELEV.	NOTES	ADDRESS	DIFF SIZE	DIFF ELEV.	NOTES
							CK E.P. Residential

DATE 7-29-80 SURVEYED BY: EOP Sh. No. 4

Zone 1

Exhibit 5

DAMAGES INCLUDED IN SURVEY

1. Basement - structural cleanup and other: basement or cellar floors, Sub-basement foundation, exterior and interior walls, cleaning and carting.

- Utilities: Heat, electricty, plumbing, gas, and air conditioning including losses for possible damage to, removal and replacement of heating plant and hot water heater, electrical board, water and sewage pipes, sink and lavatory, gas meter and air conditioning unit.

- Content: Furnishing, tools, sporting equipment, garden furniture and storage chests.

2. Outside - grounds, fencing, driveway, storage sheds, pool and landscaping.

3. 1st floor and above - fist floor interior and exterior walls, windows, doors and cabinets, fixtures, plumbing and electrical equipment, outlets, and ceilings.

- Contents: Furnishings, refrigerator, freezer, rugs, drapes, clothing, food, pots and pans, dishes, silverware, small appliances, and large applicances (providing they are not in the basement).

- Garage: Car, structure and contents.

4. Non-Physical Losses

One hundred dollars per day per family was estimated for the expense of being out of owned homes. This includes the cost of shelter and food. In the case of rental units, the actual or estimated rent was used. This varied from unit to unit. In the case of single person $60 per day is reasonable for lodging, food and incidentials, at this particular time and in this area. Emergency clothing and rented auto.

$40.00 for a room $15.00 for rented car
$20.00 for food and incidentals, possibly clothing.

This $100.00 figure for families and the $60.00 per single person were average figures.

Exhibit 6.1
Category Damage

Modern 2 Family
Colonial 1 Family or 2 Family, 2-1/2 Story
Cape (medium) 1-1/2 Story 1 Family
Special Frame 2 Story, 2 Family
Ranch (medium)
Raised Ranch 1 and 2 Family

		Estimated Value
1. Basement Area:		
Electrical Panel		$ 500
Gas		$ 200
Heating Plant		$ 2,200
Tools		$ 500
Cloths		$ 1,500
Hot Water Heater		$ 500
Sporting Goods		$ 200
2. 1st Floor Area:		
Normal Size	Floor	$ 2,000
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 2,500
	Foundation	$ 4,000
	Cellar Floor	$ 3,000
	Fence	$ 500
	Driveway	$ 500
	Pool	$ 5,500
	Indoor Furniture	$18,000
	Outdoor Furniture	$ 200
	Automobiles	$ 4,000
	Garage	$ 3,000

Exhibit 6.2
Category Damage

Cottage 1 Family
Bungelow (Small) 1 Family
Mobile (Converted) 1 Family
Ranch (Small)

		Estimated Value
1. Basement Area:		
Electrical Panel		$ 500
Gas		$ 200
Heating Plant		$ 2,200
Tools		$ 200
Cloths		$ 1,500
Hot Water Heater		$ 500
Sporting Goods		$ 200
2. 1st Floor Area:		
Normal Size	Floor	$ 2,000
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 2,000
	Foundation	$ 3,000
	Cellar Floor	$ 2,000
	Fence	$ 400
	Driveway	$ 1,500
	Pool	$ 5,000
	Indoor Furniture	$12,000
	Outdoor Furniture	$ 100
	Automobiles	$ 3,500
	Garage	$ 2,000

Exhibit 6.3
Category Damage

Ranch (Modified to Garrison) 1 Family
Ranch (Modified to Colonial) 1 Family
Ranch (Large)

		Estimated Value
1. Basement Area:		
Electrical Panel		$ 500
Gas		$ 200
Heating Plant		$ 2,200
Tools		$ 800
Cloths		$ 3,000
Hot Water Heater		$ 500
Sporting Goods		$ 500
2. 1st Floor Area:		
Normal Size	Floor	$ 2,000
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 2,500
	Foundation	$ 5,000
	Cellar Floor	$ 4,000
	Fence	$ 1,000
	Driveway	$ 2,500
	Pool	$ 7,500
	Indoor Furniture	$30,000
	Outdoor Furniture	$ 2,500
	Automobiles	$ 5,000
	Garage	$ 3,000

Exhibit 6.4
Category Damage

Floodproofed Single

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 500
	Gas	$ 200
	Heating Plant	$ 2,200
	Tools	$ 500
	Cloths	$ 2,500
	Hot Water Heater	$ 500
	Sporting Goods	$ 500
2.	1st Floor Area:	
	Normal Size Floor	$ 2,000
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 2,500
	Foundation	$ 5,000
	Cellar Floor	$ 800
	Fence	$ 1,000
	Driveway	$ 2,000
	Pool	$ 5,500
	Indoor Furniture	$25,000
	Outdoor Furniture	$ 1,500
	Automobiles	$ 5,000
	Garage	$ 3,000

Exhibit 6.5
Category Damage

Floodproofed Double

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 1,000
	Gas	$ 400
	Heating Plant	$ 3,600
	Tools	$ 600
	Cloths	$ 4,000
	Hot Water Heater	$ 1,000
	Sporting Goods	$ 600
2.	1st Floor Area:	
	Normal Size Floor	$ 2,000
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 3,000
	Foundation	$ 5,000
	Cellar Floor	$ 1,000
	Fence	$ 4,000
	Driveway	$ 3,000
	Pool	$ 5,000
	Indoor Furniture	$16,000
	Outdoor Furniture	$ 1,000
	Automobiles	$ 7,000
	Garage	$ 5,000

Exhibit 6.6
Category Damage

Spilt Level Single
Contemporary Tri-Level 1 Family

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 500
	Gas	$ 200
	Heating Plant	$ 2,200
	Tools	$ 500
	Cloths	$ 2,500
	Hot Water Heater	$ 500
	Sporting Goods	$ 500
2.	1st Floor Area:	
	Normal Size Floor	$ 1,500
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 2,500
	Foundation	$ 4,000
	Cellar Floor	$ 2,500
	Fence	$ 500
	Driveway	$ 1,500
	Pool	$ 5,000
	Indoor Furniture	$18,000
	Outdoor Furniture	$ 1,000
	Automobiles	$ 5,000
	Garage	$ 3,000

Exhibit 6.7
Category Damage

Split Leve 2 Family
Contemporary Tri-Level 2 Family

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 800
	Gas	$ 400
	Heating Plant	$ 2,200
	Tools	$ 700
	Cloths	$ 4,000
	Hot Water Heater	$ 500
	Sporting Goods	$ 700
2.	1st Floor Area:	
	Normal Size Floor	$ 1,500
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 2,500
	Foundation	$ 4,000
	Cellar Floor	$ 2,000
	Fence	$ 500
	Driveway	$ 1,500
	Indoor Furniture	$15,000
	Outdoor Furniture	$ 1,000
	Automobiles	$ 5,000
	Garage	$ 4,000

Exhibit 6.8
Category Damage

Summer Single
Summer Cottage 1 Family

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 500
	Gas	$ 200
	Tools	$ 200
	Cloths	$ 1,500
	Hot Water Heater	$ 500
	Sporting Goods	$ 1,000
2.	1st Floor Area:	
	Normal Size Floor	$ 1,000
	Room	$ 500
	Ceiling	$ 300
	Roofing	$ 2,000
	Foundation	$ 1,500
	Cellar Floor	$ 500
	Driveway	$ 1,000
	Indoor Furniture	$ 3,500
	Outdoor Furniture	$ 200
	Automobiles	$ 3,500

Exhibit 6.9
Category Damage

Summer Double
Summer Double Cottage 2 Family

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 600
	Gas	$ 400
	Heating Plant	$ 1,000
	Tools	$ 200
	Cloths	$ 2,500
	Hot Water Heater	$ 1,000
	Sporting Goods	$ 1,500
2.	1st Floor Area:	
	Normal Size Floor	$ 2,000
	Walls	$ 500
	Ceiling	$ 300
	Roofing	$ 5,000
	Foundation	$ 3,000
	Cellar Floor	$ 1,000
	Fence	$ 300
	Driveway	$ 2,000
	Indoor Furniture	$ 8,500
	Outdoor Furniture	$ 500
	Automobiles	$ 5,000

Exhibit 6.10
Category Damage

Three Family Frame 3 Story

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 800
	Gas	$ 600
	Heating Plant	$ 6,600
	Tools	$ 1,000
	Cloths	$ 1,800
	Hot Water Heater	$ 1,500
	Sporting Goods	$ 900
2.	1st Floor Area:	
	Normal Size Floor	$ 2,000
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 3,000
	Foundation	$ 3,000
	Cellar Floor	$ 4,000
	Fence	$ 500
	Driveway	$ 1,500
	Indoor Furniture	$18,000
	Outdoor Furniture	$ 500
	Automobiles	$ 4,000
	Garage	$ 2,000

Exhibit 6.11
Category Damage

6 Family Frame 3 Story

		Estimated Value
1.	Basement Area:	
	Electrical Panel	$ 1,600
	Gas	$ 1,200
	Heating Plant	$13,200
	Tools	$ 1,200
	Cloths	$ 1,200
	Hot Water Heater	$ 3,000
	Sporting Goods	$ 1,200
2.	1st Floor Area:	
	Normal Size Floor	$ 2,000
	Walls	$ 1,000
	Ceiling	$ 500
	Roofing	$ 6,000
	Foundation	$ 6,000
	Cellar Floor	$ 8,000
	Fence	$ 2,000
	Driveway	$ 1,000
	Indoor Furniture	$24,000
	Outdoor Furniture	$ 800
	Automobiles	$ 4,000
	Garage	$ 4,000

RECURRING FLOOD LOSSES

Flooding has been a serious problem at Roughans Point for many years as evidenced by the construction of seawalls and placement of riprap to protect the area. The existing flood protection measures are not effective. Interior drainage is addressed by an MDC pumping station, although it has been inadequate to deal with the ponding problems.

There are 309 homes within the flood plain, 291 residential structures and 18 commercial/public structures. A market value survey was done of the Roughans Point area east of Winthrop Parkway by Real Estate Divison personnel and their findings are in Appendix D. Market values averaged $59,100 per residential ownership. Acqusition was ruled out as impractical. The cost for properties only east of Winthrop Parkway was estimated at $11,000,000. Other flood protection alternatives considered were far less expensive.

The most severe flood of record at Roughans Point was the 1978 storm which was a 100-year event. Flood damage was extensive throughout Revere, although Roughans Point was damaged more severely than other sections of the city. People were unable to return to their homes in 1978 for up to nine days. The NED damage survey shows that under present conditions if floodwaters were to reach the 1978 flood crest, losses would amount to $9.5 million*. A breakdown of total recurring losses by elevation is presented in Tables E-1 and E-2. Included is information on the 100 year, 500 year, and SPN events.

TABLE E-1
Recurring Losses*
Roughan's Point
(Residential, Commercial and Public Buildings)

Interior Flood Elevation (NGVD)	Return Frequency (Years)	No. Structures Affected	Damages (Dollars Feb 82)
4	1.00	-	-
5	1.11	45	12,100
6	1.66	90	81,300
7	2.50	124	340,800
8	5.00	167	1,078,500
9	10.00	231	2,447,600
10	20.00	284	4,858,100
11	50.00	297	7,269,200
12	100.00	301	9,478,800
13	500.00	305	11,793,400
14	2,000.00	309	14,340,900
15	10,000.00	309	16,781,400

*Excludes highways, public utilities and emergency costs. Includes physical and non-physical losses to public, commercial and residential buildings.

TABLE E-2
Recurring Losses
Roughans Point
(Highways, Public Utilities)

Interior Flood Elevation (Ft., NGVD)	Damages (Dollars Feb 82)
0.8	0
1.8	4,000
2.8	10,000
3.8	14,000
4.8	20,000
5.8	50,000
6.8	80,000
7.8	100,000
8.8	180,000
9.8	300,000
10.8	450,000
11.8	600,000
12.8	600,000
13.8	600,000
14.8	600,000

Additional evidence of the flooding problem at Roughans Point is provided by the Flood Insurance Administration data on claims paid in Revere. Claims paid over the last 7 years are displayed in Table E-3.

Table E-3
Claims Paid by FIA at Revere

Year	No. of Policies	Claims Paid ($)
1974	54	43,700
1975	1	500
1976	7	7,400
1977	18	30,300
1978	281	2,526,700
1979	451	1,316,000
1980	7	7,900

The table shows that Revere as a whole suffers a substantial amount of damage on a faily regular basis. It is estimated that Roughans Point suffers up to half of all damages in the city. For the 1979 event, over $1.3 million was paid out on 451 policies in Revere. Hydrological information indicates that the 1979 flood was about a 3-year event. This means that 451 structures can be expected to suffer nearly $3,000 each in damages every third year. The $3,000 figure can be considered conservative since it fails to account for the $200 flood insurance deductible and because several categories of losses (grounds, nonphysical, motor vehicles, etc) are not claimable under the flood insurance program. Also, an estimate of only 85% of the structures at Roughans Point are covered by flood insurance. For Revere as a whole, the participation rate is even less.

ANNUAL FLOOD LOSSES

In order to compute expected annual flood losses and benefits damage survey data was coded and input into the "Interactive Nonstructural Analysis" computer program developed by the Hydrologic Engineering Center in Davis, California. The program computes expected annual damage on a structure by structure basis. Stage-damage information is input for each structure along with the elevation of the ground and the elevation of the structure's first floor. Stage-frequency data is inserted and linked to the stage-damage information in order to compute damage-frequency data and expected annual damages. These damages represent the average annual flood losses that can be expected to occur given the entire range of probabilities associated with floods of different magnitudes. Flood inundation reduction benefits are calculated by inputting the modified stage-frequency data associated with the proposed project and subtracting expected annual losses with the project from expected annual losses under the without project condition. An example of the computer output is provided in exhibit 7 at the end of this appendix. In addition to structural losses, other categories of flood losses and associated costs were estimated for the project area. Average annual flood loses total $1,338,000 at the Oct. '83 price level and are displayed in the table below.

TABLE E-4
AVERAGE ANNUAL FLOOD LOSSES

Category	Dollar Value	Percentage
Structural (incl. Res & Com/Pub)	$980,000	73.2%
Highway and Utilities	116,000	8.7
Future Contents Value (Affluence)	138,000	10.3
Flood Insurance Overhead	13,000	1.0
Emergency Costs	83,000	6.2
Existing Pump Station Operating Costs	8,000	0.6
TOTAL	$1,338,000	100%

FLOOD INUNDATION REDUCTION

Flood inundation benefits which have been computed as described above for Plan A-5(4) are displayed in Table E-5.

Table E-5
Flood Inundation Reduction Annual Benefits* (OCT '83 P.L.)

Condition	Residential	Commercial Public	Highways Utilities	Total
Without	$ 861,000	$ 119,000	$ 116,000	$1,096,000
With Structural Project	$ 53,000	$ 6,000	$ 22,000	$ 81,000
% Damages Prevented	93%	95%	81%	93%
Benefit	$ 808,000	$ 113,000	$ 94,000	$1,015,000

*Highway/utilities benefit hand computed, stage-damage and damage-frequency curves on Plates E-1 and E-2.

AFFLUENCE BENEFITS

Affluence benefits are based on the idea that as real per capita income increases, the real value of residential contents will increase. As contents value grows the potential dollar amount of damages grows. The OBERS regional growth rate for per capita income is used as the basis for increasing the real value of residential contents in the future. OBERS information (1980) shows that per captia income in the Boston SMSA is expected to increase as shown below.

Table E-6
Per Capita Income - Boston SMSA

Year	Per Capital Income	Annual Compound Growth Rate
1978	$ 5,557	1978-1985 - .030625
1985	$ 6,862	1985-1990 - .024375
1990	$ 7,737	1990-2000 - .019375
2000	$ 9,372	2000-2030 - .0190625
2030	$16,499	-

According to the NED damage survey the 282 houses at Roughans Point are in good condition and therefore warrant affluence benefits. The survey information reveals that residential contents are currently equal to approximately 43% of structure value. According to WRC regulations the value of contents may not exceed 75% of the structural value of the residence unless empircal evidence proves otherwise. It is anticipated that contents value at Roughans Point will increase from its present 43% to 75% of residential structure value in the future. At the rates of growth shown in Table E-6 it will take approximately 27 years for this to take place. Annual residential contents losses for the 282 structures will increase as shown in Table E-7.

Table E-7
Annual Losses - Residential Contents

Year	Annual Losses (Feb. '82 P.L.)
1982	$315,000
1985 - (First Year of Project)	$345,000
1990	$389,000
2000	$471,000
2009 - (Max. Value 75%)	$550,000
2035	$550,000

Over the first 24 years of the project lifetime residential contents losses will increase from $345,000 to $550,000 or a total increase of $205,000. On an average annual equivalent basis, the increased losses are $96,000 [$205,000 x .4692224 (avg. annual equivalent factor, 8-1/8%, 24 yr. growth, 100 yr. life)] over the 100 year project life. Growth in contents value from present year to first year of project life amounts to $30,000. Affluence benefits obtained through project implementation amount to approximately 94 percent of total contents losses or $129,000 at the October 1983 price level.

EMERGENCY COSTS

Emergency costs are defined as costs which result from emergency activities prior to, during, and after a flood. Emergency costs include expenses for flood emergency centers, communication facilities not otherwise needed, temporary evacuation assistance, flood fighting materials and personnel, additional police and fire protection, and public clean-up.

Available data on experienced emergency costs at Roughans Point consists primarily of information obtained after the February 1978 flood. During this storm a state of emergency was declared in Massachusetts and the President of the United States declared Massachusetts a "major disaster area". The Federal Disaster Assistance Administration (FDAA) opened a Disaster Assitance Center in Revere. Also, Follow-up Assistance on Service Teams (FASTS) were organized. "Project Concern" a six-month crisis counseling service was established by the Massachusetts Department of Mental Health. The American Red Cross, the Massachusetts National Guard and the regular U.S. Army also provided assistance. A list of agencies involved in emergency operations during the 1978 storm and the subsequent rehabilitation is provided in Table E-8.

Activities associated with the 1978 flood are documented more fully in the February 1979 Corps report, "Blizzard of '78, Coastal Storm Damage Study." Although the aim of that study was to allocate flood costs and expenses to the community in which losses occurred, in many instances data would be summarized at the State or, in some cases, the city level. The summarized information shows that total public and private losses and expenses amounted to over $257,000,000 for the Commonwealth of Massachusetts. The comparable figure for the city of Revere is $16,140,000. Costs in Revere are, therefore, estimated to account for approximately 6% of all State flood costs.

The figures discussed thus far refer to all costs and losses, not just emergency costs. In many instances it is difficult to differentiate between emergency costs and funds derived from regular operating budgets. Investigation reveals that the best estimate of true emergency costs is the list of funds made available from the President's Disaster Relief Fund. Moneys made available to the Commonwealth of Massachusetts from this fund are as follows.

Temporary Housing	$12,500,000
Disaster Unemployement Assistance	$ 300,000
Individual and Family Grants	$ 4,000,000
Crisis Intervention	$ 461,526
FCO Mission Assignment	$ 50,000
Public Assistance	$20,691,695
TOTAL	$38,003,221

Table E-8
Emergency Organization Involved
Revere 1978

1. Housing and Urban Development (HUD)
    - Temporary Housing
    - Federal Insurance Administration
    - Minimal Repair Program

2. Small Business Adminstration (SBA)
    - Homes and Personal Loans
    - Business Loans

3. Department of Labor (DOL)
    - Disaster Unemployment Insurance

4. Department of Agriculure (DOA)
    - Food and Nutrition Service (Food Stamps)
    - Farmers Homes Administration

5. Federal Disaster Assistance Administration (FDAA)

6. Internal Revenue Service (IRS)
    - Casualty Loss

7. Community Services Administration (CSA)
    - Grants to Local Communities
    - Action Agencies for Food and Fuel

Table E-8 (Cont.)

8. Heal, Education and Welfare (HEW) - Offices on
   Aging Grants for Speical Needs of Elderly
   and Education

9. Federal Highway Administration (FHA)
   Federal Aids to Roads and Highways

10. U.S. Army Corps of Engineers (CE)
    Operations and Maintenance
    Emergency Rehabilitation of Flood Projects

11. U.S. Army, Massachusetts
    Massachusettss National Guard

12. U.S. Economic Development Administration
    Massachusetts Disaster Recovery Team
    (Operation and Coordination)

13. Mission Assignments, Massachusetts (Reimbursed by FDAA)
    U.S. Army Corps of Engineers
    U.S. Army New England Division, Corps of Engineers
    Environmental Protection Agency
    Federal Aviation Agency
    Federal Highway Administration
    General Services Administration

14. U.S. Coast Guard, Massachusetts
    Minor Aids to Navigation

In order to estimate the portion of these emergency costs which were expended on Roughans Point several assumptions and procedures were required. Because NED damage surveys already include expenses for temporary housing this item was eliminated from the fund total, resulting in a new total of approximately $25,500,000. Next, because it had been determined that Revere accounted for 6% of total State flood costs, it was assumed that Revere accounted for 6% of State emergency costs. This resulted in an estimate of $1,500,000 in emergency costs for Revere during the 1978 flood.

Information from several damage surveys of Revere indicate that Roughans Point generally suffers 50 to 70% of all flood losses in the city. The $1,500,000 Revere total was, therefore, multiplied by .5 to obtain estimated emergency costs of $750,000 for Roughans Point in 1978. It should be noted that this figure may be somewhat conservative since no effort has been made to quantify the opportunity costs of the flood emergency (e.g., its value of time lost to individuals due to traffic diversion, time spent applying for disaster relief, loans, etc.)

Average annual emergency costs were computed by relating stage-emergency cost data to stage-frequency data using the 1978 flood as a base. Emergency costs of $750,000 at the 1978 flood elevation of 11.8 feet represents 8.5 % of physical and nonphysical recurring losses to public, commercial and private buildings at that elevation. The assumption that this relationship holds true for other elevations enabled the development of the natural stage-emergency costs information displayed on Plate E-3.

When the stage-emergency costs information is combined with stage-frequency data, average annual emergency costs can be computed as shown on Plate E-4. Analysis of the information shows expected average annual emergency costs of $76,000. Implementation of the project would reduce this to $5,000, resulting in an average annual benefit of $71,000. In addition to emergency costs stated above, there is also an additional annual cost of $7,000 incurred in the operation and maintenance of the existing pumping station at Roughans Point. Since this existing cost is included in the project's annual cost, it is therefore included in project benefits for reduction of flood mitigation costs. Total benefits amount to $85,000 at the updated Oct. 1983 price level. ($78,000 x 1.095)

Benefits From the Reduction in Insurance Overhead

A national cost for the flood insurance program is its administrative costs. The cost of servicing flood insurance policies is determined based upon the average cost per policy, including agent commission, and the cost of servicing and adjusting claims. This benefit is considered for all structures eligible for flood insurance. In the case of Roughans Point, there are 309 structures affected by flooding. Therefore, it is assumed that 309 policies which would have an administrative overhead cost of $39 per policy can be written. The average annual benefit is equal to the annual cost of the administrative overhead, or approximately $13,000 (OCT. '83 P.L.)

Other Benefits

Future inundation reduction benefits represent the value of reducing future flood losses to activities which will use the floodplain even without project implementation. Since there is little room for development at Roughans Point, it is assumed that existing losses (with the exception of affluence) provide a good indication of future losses and that any development that does occur would replace similar existing activities. Additional future inundation reduction benefits are therefore declared to be negligible.

Location benefits consist of the value provided by making the flood plain available for new uses. Intensification benefits arise when a project allows an activity to modify its operation by utilizing its land more productively. These potential benefits were studied and also found to be insignificant at Roughans Point.

Employment benefits result from the use of otherwise unemployed or underemployed labor in the construction or implementation of a plan. Employment benefits were not applicable since the city of Revere does not meet WRC qualifyng standards for substantial and persistent unemployment.

In addition to the benefits previously described, intangible benefits would accrue if the project is implemented. These benefits include a reduction in health hazards caused by polluted floodwaters and a potential improvement in the social and economic well-being of residents and economic activities in the area.

ECONOMIC JUSTIFICATION

Presented below are the annual benefits, costs, and benefit-cost ratio for Plan A5(4). As can be seen, the benefit-cost ratio is greater than unity and the project is therefore economically justified.

Annual Benefits. (Oct. 1983 Price Level)

Flood Inundation Reduction	$1,015,000
Affluence	129,000
Prevention of Emergency Costs	85,000
Reduction in Insurance Overhead	13,000
TOTAL	$1,242,000
Annual Costs:	$ 780,000
Benefit/Cost Ratio	1.6 to 1

DEVELOPMENT OF NED PLAN AND NET BENEFIT MAXIMIZATION

Plan A5(4) was selected as the recommended plan since it maximizes net benefits and therefore makes the greatest contribution to National Economic Development.

Update of Stage 2 Plans

Twenty-six plans, which covered the range of structural and non-structural alternatives, were updatd and evaluated through Stage 2 planning. The criterion for selecting the plan which would undergo further detailed evaluation in Stage 3 was the greatest dollar amount of annual net benefits. Reference to Table 10, pg III-18 indicates that Plan A-5 was chosen as the preliminary NED plan since it produced annual net benefits of $446,000 (Feb. 1982 price level). To confirm Plan A-5 as the NED plan further comparison was made to Plans A1 and A9 since these plans has identical shorefront berm slopes (1 on 3) and interior drainage provisions but different elevations of shorefront protection. Of the three plans only Plan A-5 exhibited a positive level of net benefits, even though A9 prevented 100 percent of annual damages and A1 prevented 50 percent.

Maximization of Net Benefits

In an effort to arrive at the dimensions of the selected plan which would result in the ultimate maximization of net benefits, nine supplemental plans, A5(2) through A5(10), were formulated. With the dimensions of Plan A5 serving as a base (shorefront at el. 17, 1 on 3 slope, and backshore at el. 12) the berm elevations were varied for the nine supplemental plans. Plans A5(2) through A5(6) hold shorefront protection constant at el. 17 and vary backshore protection from el. 10 to el. 13. Plans A5(7) through A5(10) hold the backshore berm at el. 12 and vary the elevation of the shorefront berm from el. 16 to 18.5. Costs and benefits for each supplemental plan were estimated and net benefits determined. To obtain economic data for some of the supplemental plans, cost curves and benefit curves were constructed. The shape and magnitude of these curves were based on the costs and benefits for the following five plans which were estimated using traditional methods.

Plan	Shorefront Berm el.	Backshore Berm el.	% Reduction in Damages
A1	14	11	50%
A5	17	12	94%
A5(4)	17	11	93%
A5(9)	17.5	12	95%
A9	22	14	100%

Pertinent economic data for all supplemental plans are summarized in the table below. With annual net benefits of $430,000, Plan A5(4) is the NED Plan. For additional detail on the supplemental plans, refer to Table 11, pg. III-23.

Table E-9
Supplemental Plans for Benefit Maximization of NED Plan
(In 000's - Feb. '82 Price Level)

Plan	Shorefront Berm el.	Backshore Berm el.	Annual Benefits	Annual Costs	Benefit-Cost Ratio	Net Benefits
A5	17'	12'	$1,145	$727	1.57	$418
A5(2)	17	10	1,125	704	1.6	421
A5(3)	17	10.5	1,130	704.5	1.6	425.5
A5(4)	17	11	1,135	705	1.6	430
A5(5)	17	11.5	1,140	716.1	1.59	424
A5(6)	17	13	<1,145	765.7	<1.5	<379.3
A5(7)	16	12	1,060	709.8	1.49	350
A5(8)	16.5	12	1,110	718.2	1.55	392
A5(9)	17.5	12	1,161	750.0	1.55	411
A5(10)	18.5	12	1,200	875.3	1.37	324.7

EXHIBIT 7

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++++++++++++++++++++++++++++++++++++++
+ STRUCTURE INVENTORY PREPROCESSOR +
+  ++++++++++++++++++++++++++++++++++
    ?RACTIVE NONSTRUCTURAL ANALYSIS PACKAGE FEB 1980 VERSION
 R..GHANS POINT,REVERE,MA
 JANUARY 1982 RUN  AUGUST 1980 PL

DAMAGE FUNCTION  1      2 FAMILY 2 STORY CONCRETE BLOCK MODERN-STRUCTURE

STAGE
        0.00      .50     1.00     1.50     2.00     2.50     3.00     3.50     4.00     4.50
        5.00     5.50     6.00     6.50     7.00     8.00     9.00    10.00

DAMAGE
        0.00     1.00     2.00     3.00     4.00     4.90     5.80     5.90     6.00     7.00
        8.00     8.50     9.00     9.50    10.00    11.90    13.80    14.90

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

DAMAGE FUNCTION  2      2 FAMILY 2 STORY CONCRETE BLOCK MODERN-UTILITY

STAGE
        0.00      .50     1.00     1.50     2.00     2.50     3.00     3.50     4.00     4.50
        5.00     5.50     6.00     6.50     7.00     8.00     9.00    10.00

DAMAGE
        0.00      .20      .40      .70      .90     1.20     1.50     1.80     2.00     2.50
        3.00     3.30     3.50     3.50     3.50     3.50     3.50     3.50

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

DAMAGE FUNCTION  3      2 FAMILY 2 STORY CONCRETE BLOCK MODERN-CONTENTS

STAGE
        0.00      .50     1.00     1.50     2.00     2.50     3.00     3.50     4.00     4.50
        5.00     5.50     6.00     6.50     7.00     8.00     9.00    10.00

DAMAGE
        0.00     1.20     2.30     5.00     7.60     9.80    12.00    14.00    15.90    16.90
       17.90    17.90    17.90    17.90    17.90    18.70    19.40    20.60

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

DAMAGE FUNCTION  4      2 FAMILY 2 STORY CONCRETE BLOCK MODERN-GROUNDS

STAGE
        0.00      .50     1.00     1.50     2.00     2.50     3.00     3.50     4.00     4.50
        5.00     5.50     6.00     6.50     7.00     8.00     9.00    10.00
```

```
REACH     1      ROUGHAN'S POINT

FREQUENCIES
      99.00      95.00      50.00      20.00      10.00       5.00       2.00       1.00        .20        .10
        .01

FLOOD PEAKS
      1000.      2000.      3000.      4000.      5000.      6000.      7000.      8000.      9000.     10000.
     11000.

DATUM ELEVATION
       0.00

STAGES FOR RATING CURVE
       4.60       4.80       6.50       8.00       9.10       9.90      11.00      11.70      13.00      13.60
      15.00

FLOWS FOR RATING CURVE
      1000.      2000.      3000.      4000.      5000.      6000.      7000.      8000.      9000.     10000.
     11000.

STAGES FOR FLOOD PEAKS
       4.60       4.80       6.50       8.00       9.10       9.90      11.00      11.70      13.00      13.60
      15.00

REFERENCE FLOOD ELEVATIONS
       8.60       9.10       9.50      10.50

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

STRUCTURE    100       89 ATLANTIC AVENUE
PHOTO ID*******

  CATEGORY      VALUE  FUNCTION
  STRUCTUR         1.        11
  UTILITY          1.        12
  CONTENTS         1.        13
  GROUNDS          1.        14
  NONPHYS          1.        15

REFERENCE FLOOD ELEVATIONS AT STRUCTURE
       8.60       9.10       9.50      10.50

FREQUENCIES
     99.000     95.000     50.000     20.000     10.000      5.000      2.000      1.000       .200       .100
       .010
```

0.00

STAGES FOR RATING CURVE

4.60	4.80	6.50	8.00	9.10	9.90	11.00	11.70	13.00	13.60
15.00									

FLOWS FOR RATING CURVE

1000.	2000.	3000.	4000.	5000.	6000.	7000.	8000.	9000.	10000.
11000.									

STAGES FOR FLOOD PEAKS

4.60	4.80	6.50	8.00	9.10	9.90	11.00	11.70	13.00	13.60
15.00									

REFERENCE FLOOD ELEVATIONS

8.60	9.10	9.50	10.50

++

STRUCTURE 100 89 ATLANTIC AVENUE
PHOTO ID*******

CATEGORY	VALUE	FUNCTION
STRUCTUR	1.	11
UTILITY	1.	12
CONTENTS	1.	13
GROUNDS	1.	14
NONPHYS	1.	15

REFERENCE FLOOD ELEVATIONS AT STRUCTURE

8.60	9.10	9.50	10.50

FREQUENCIES

99.000	95.000	50.000	20.000	10.000	5.000	2.000	1.000	.200	.100
.010									

ELEVATIONS AT STRUCTURE FOR FREQUENCY CURVE

4.60	4.80	6.50	8.00	9.10	9.90	11.00	11.70	13.00	13.60
15.00									

	ELEV	FREQ
GROUND	9.75	5.682
1ST FLOOR	12.75	.281
0 DAMAGE	9.75	5.682

LEVEL OF PROTECTION
17.599

X-COORD	0.00
Y-COORD	0.00
USE	RES
TYPE	3ST-
PERMEABLTY	HI

	OPENINGS
BELOW 1ST	0
AT 1ST	0
WINDOWS	0

FC 'NDATION	BLOC
FI ' MATL	WOOD
S. MATL	WOOD
CONDITION	QUES

HISTORICAL
ENVIRON

FIELD ASSESSMENT (1=YES, 0=NO, -1=UNKNOWN)

CLOSURES	0
RAISING	-1
WALL	1
REMOVAL	0
PONDING	-1

STAGE FOR FREQUENCY CURVE

-5.15	-4.95	-3.25	-1.75	-.65	.15	1.25	1.95	3.25	3.85
5.25									

ANALYSIS FREQUENCIES

50.000	20.000	10.000	6.667	4.000	3.333	2.000	1.333	1.000

DEPTHS FOR ANALYSIS FREQUENCIES (RELATIVE TO 0 DAMAGE ELEV.)

0.00	0.00	0.00	0.00	.42	.68	1.25	1.69	1.95

STAGE FOR DAMAGE FUNCTION

0.00	.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
5.00	5.50	6.00	6.50	7.00	8.00	9.00	10.00		

STRUCTUR DAMAGE

0.00	5.20	5.40	5.70	5.90	5.90	7.80	11.20	14.60	17.10
19.60	20.10	20.60	21.60	22.90	30.20	30.20	30.20		

EAD
.28

UTILITY DAMAGE

GOES

HISTORICAL
ENVIRON

FIELD ASSESSMENT (1=YES, 0=NO, -1=UNKNOWN)

CLOSURES	0
RAISING	-1
WALL	1
REMOVAL	0
PONDING	-1

STAGE FOR FREQUENCY CURVE

-5.15	-4.95	-3.25	-1.75	-.65	.15	1.25	1.95	3.25	3.85
5.25									

ANALYSIS FREQUENCIES

50.000	20.000	10.000	6.667	4.000	3.333	2.000	1.333	1.000

DEPTHS FOR ANALYSIS FREQUENCIES (RELATIVE TO 0 DAMAGE ELEV.)

0.00	0.00	0.00	0.00	.42	.68	1.25	1.69	1.95

STAGE FOR DAMAGE FUNCTION

0.00	.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
5.00	5.50	6.00	6.50	7.00	8.00	9.00	10.00		

STRUCTUR DAMAGE

0.00	5.20	5.40	5.70	5.90	5.90	7.80	11.20	14.60	17.10
19.60	20.10	20.60	21.60	22.90	30.20	30.20	30.20		

EAD
.28

UTILITY DAMAGE

0.00	9.30	9.50	9.70	9.90	9.90	9.90	10.00	10.00	10.10
10.10	10.20	10.30	10.40	10.40	10.40	10.40	10.40		

EAD
.45

CONTENTS DAMAGE

0.00	6.80	8.00	8.90	9.80	11.40	12.90	15.40	17.80	20.60
23.30	25.80	28.30	32.60	36.00	36.90	36.90	36.90		

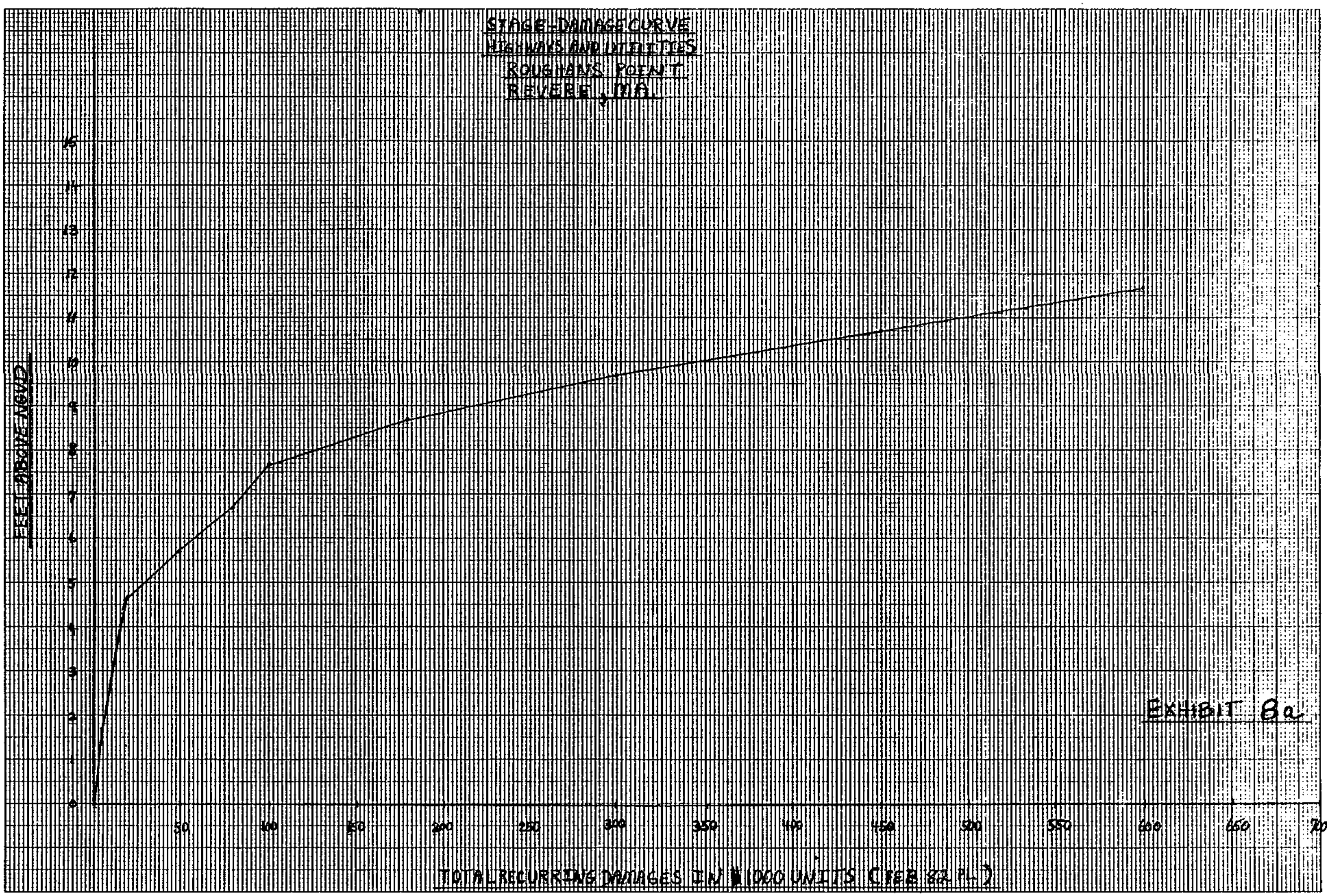
EAD
.41

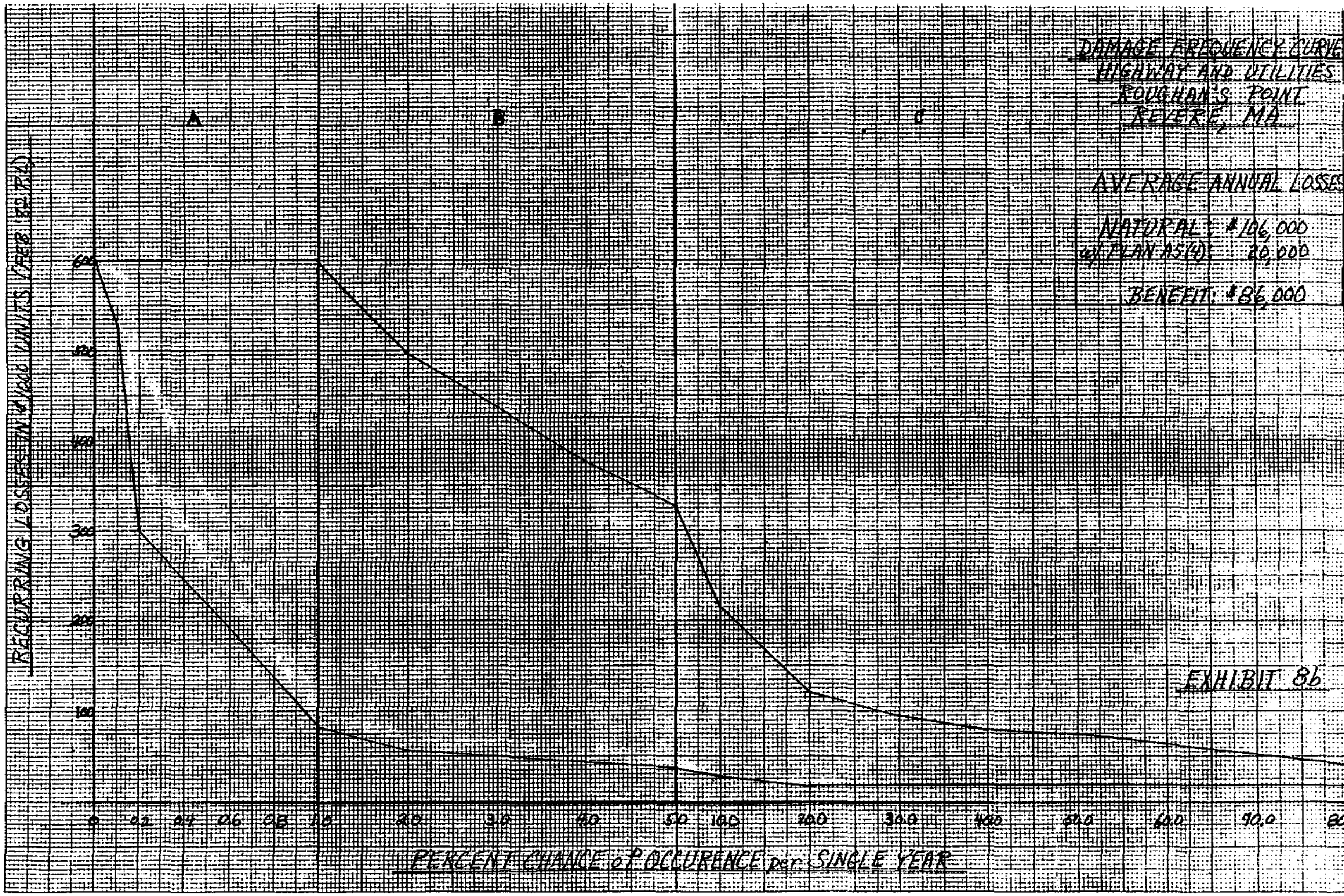
```
GROUNDS DAMAGE
    0.0(      1.30      1.50      1.70      1.80      1.90      2.00      2.10      2.20      2.30
    2.30      2.50      2.70      2.70      2.70      2.70      2.70      2.70
EAD
    .07
NONPHYS  DAMAGE
    0.00      2.70      3.10      3.90      4.60      5.30      6.20      7.40      8.10      9.20
   10.30     11.40     12.50     14.80     17.20     18.60     18.60     18.60
EAD
    .18
TOTAL DAMAGE
    0.00     25.30     27.50     29.90     32.00     34.40     38.80     46.10     52.70     59.30
   65.60     70.00     74.40     82.10     89.20     98.80     98.80     98.80
TOTAL EAD
    1.39
***** SWITCH INDEX TO IDXP
***** WRITMS, RECORD        1
***** SWITCH INDEX TO IDXS
***** WRITMS, RECORD        1
(        100        95        200)
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
STRUCTURE    102     95 ATLANTIC AVENUE
PHOTO  ()*******

   CATEGORY        VALUE  FUNCTION
   STRUCTUR          1.        11
   UTILITY           1.        12
   CONTENTS          1.        13
   GROUNDS           1.        14
   NONPHYS           1.        15

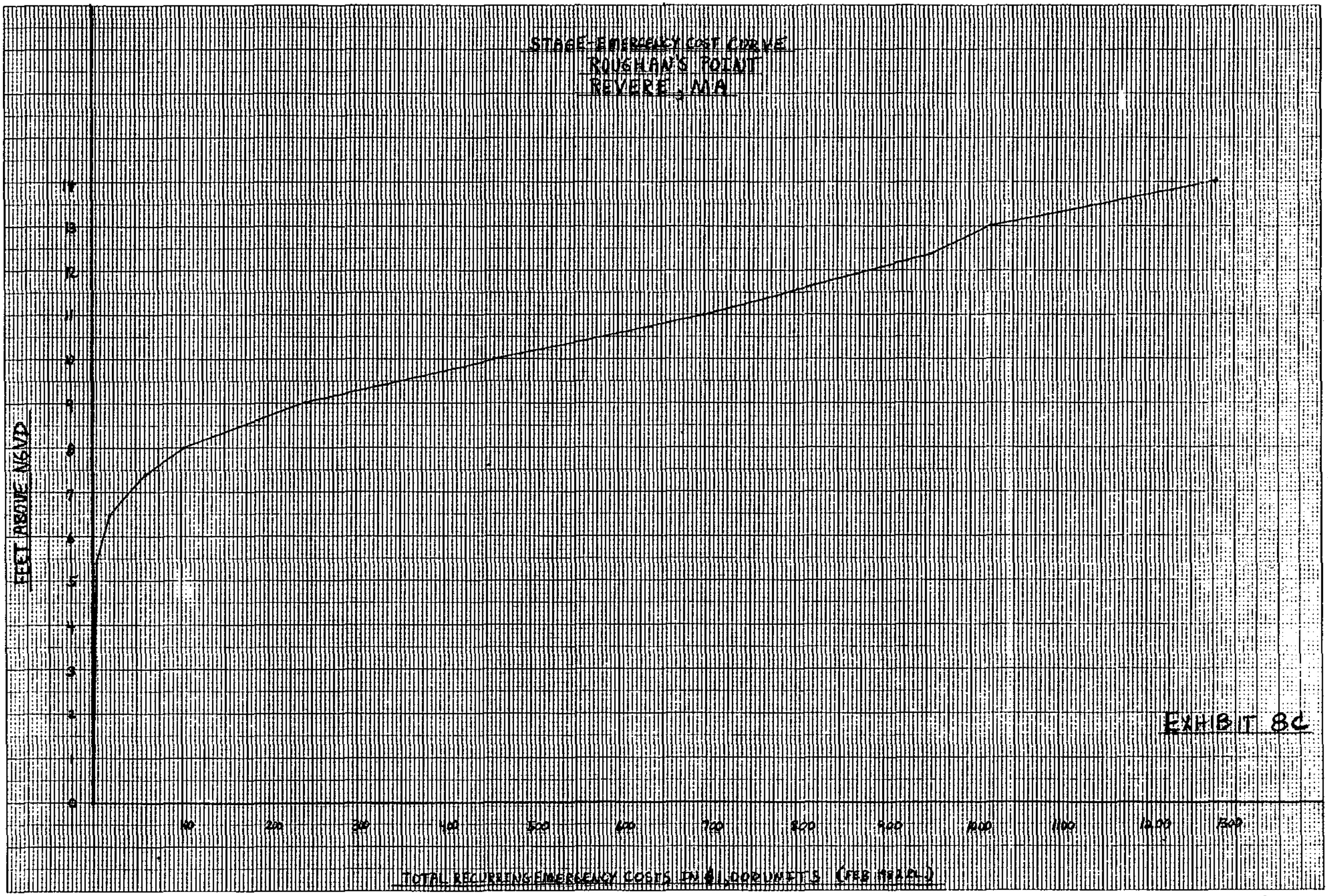
REFERENCE FLOOD ELEVATIONS AT STRUCTURE
       8.60        9.10       9.50      10.50

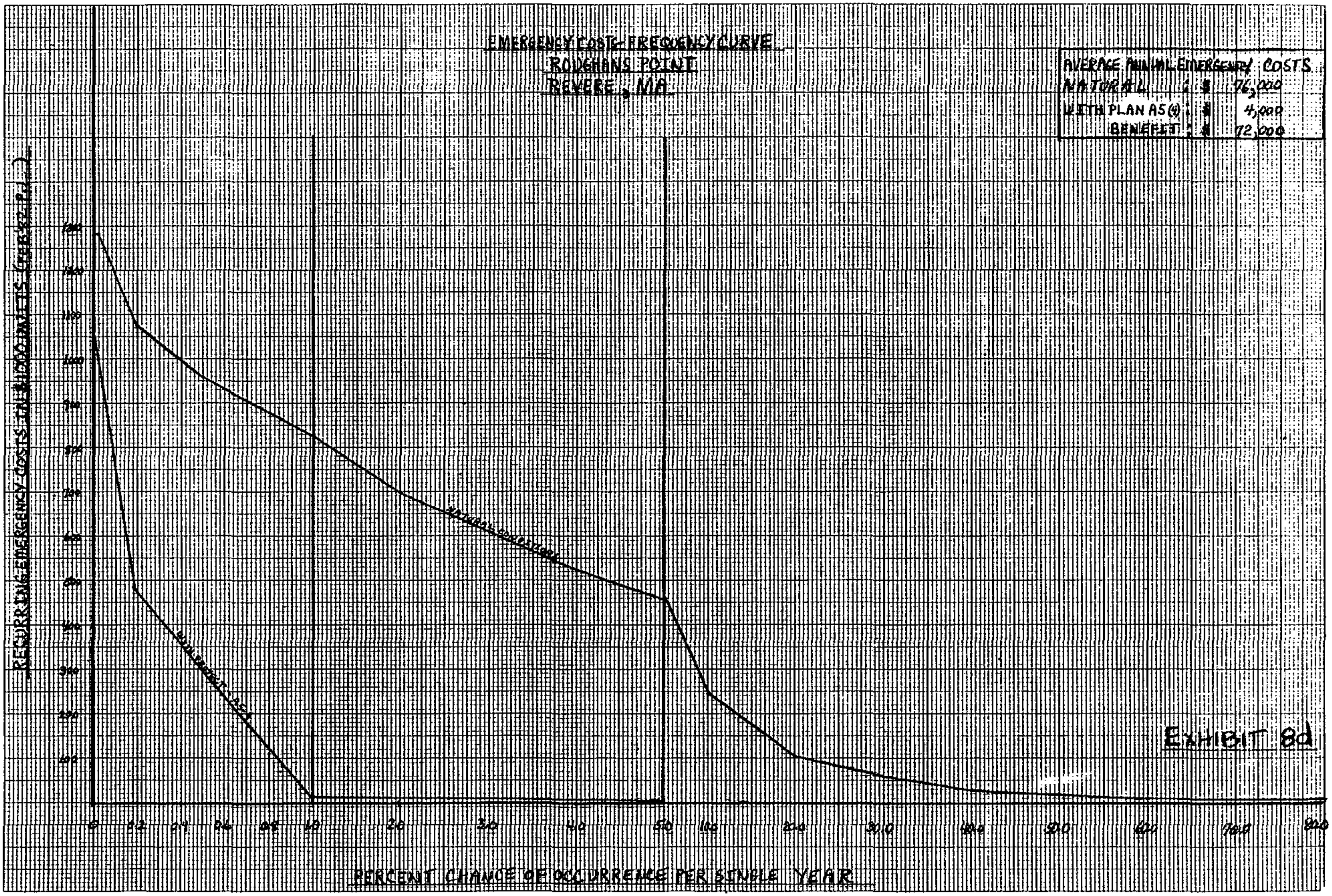
FREQUENCIES
```


STAGE-DAMAGE CURVE
HIGHWAYS AND UTILITIES
ROUGHANS POINT
REVERE, MA.
FEET ABOVE NGVD
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
50
100
150
200
250
300
350
400
450
500
550
600
650
700
TOTAL RECURRING DAMAGES IN $1000 UNITS (FEB 82 PL)
EXHIBIT 8a


DAMAGE FREQUENCY CURVE
HIGHWAY AND UTILITIES
ROUGHAN'S POINT
REVERE, MA
AVERAGE ANNUAL LOSSES
NATURAL: $106,000
w/ PLAN A5(4): 20,000
BENEFIT: $86,000
EXHIBIT 8b
A
B
C
RECURRING LOSSES IN $1000 UNITS (FEB 82 P.L.)
600
500
400
300
200
100
0
.02
.04
.06
.08
1.0
2.0
3.0
4.0
5.0
10.0
20.0
30.0
40.0
50.0
60.0
90.0
80.0
PERCENT CHANCE of OCCURENCE per SINGLE YEAR

E-36


STAGE-EMERGENCY COST CURVE
ROUGHAN'S POINT
REVERE, MA
FEET ABOVE NGVD
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
TOTAL RECURRING EMERGENCY COSTS IN $1,000 UNITS
EXHIBIT 8C


EMERGENCY COSTS-FREQUENCY CURVE
ROUGHANS POINT
REVERE, MA
AVERAGE ANNUAL EMERGENCY COSTS
NATURAL : $ 76,000
WITH PLAN AS (4) : $ 4,000
BENEFIT : $ 72,000
PERCENT CHANCE OF OCCURRENCE PER SINGLE YEAR
EXHIBIT 8d

APPENDIX F
NEWSPAPER ARTICLES

REVERE JOURNAL
REVERE, MA.
W. 8,742

NOV 10 1982

New England Newsclip

Mayor seeks endorsement of flood protection plan

Mayor George V. Colella asked for a strong endorsement of a flood protection plan for the Roughan's Point section of the city when he appeared before the Water Resource Commission on Monday.

The mayor said the city stands ready to enter into an agreement with the state to participate in the construction, maintenance and operation of the proposed facilities by providing the non-federal share of project costs.

In seeking approval and support, he made the following statement:

"I come before you today to ask your support and vote of confidence in what is one of the most important and necessary coastal flood protection projects on the Northeastern Massachusetts coastline.

The City of Revere, and more importantly, the residents of the Roughan's Point community, have waited a long time to finally receive relief from the dangerous flood conditions in this area. The critical condition which existed in the Roughan's Point area during the Blizzard of 1978 and countless other smaller storm events is evidenced by the tremendous amount of time and effort that has been dedicated by the Army Corps of Engineers in devising such a high caliber plan of flood protection which this area so badly needs — a plan which provides a competent structural solution in an area where ineffective flood control structures currently exist. This is a plan that has the support of the City of Revere and more importantly strong grass roots support within the Roughan's Point community, and is the plan which these residents have endorsed throughout the study process.

"In order to keep this project alive and allow it to materialize into a viable coastal flood protection plan, I am asking this commission to cast its vote of confidence and endorsement of this project in the form of a letter of intent that the Commonwealth of Massachusetts and City of Revere stand ready to enter into an agreement at the appropriate time to participate in the construction, maintenance and operation of the proposed facilities by providing the non-federal share of project costs — pending legislative action or other mutually agreeable arrangement.

"Ladies and gentlemen, we have come a great distance in the development of this flood relief plan only because of the hard work and cooperation of a great many people and agencies. In order for the plan to now proceed to congressional approval of the advanced planning stage, your support and endorsement is critical. I ask for your support and endorsement on behalf of the City of Revere and on behalf of the residents of Roughan's Point who have had to live with this dangerous situation for too long. If the commission does not act favorably and act immediately, all hopes of ever attaining flood relief for this residential area will be removed.

"I thank you for your consideration and your assistance."

DAILY EVENING ITEM
LYNN, MA
D. 32,440

SEP 10 1982 New England Newsclip

Roughan's Point meeting

Army Corps outlines plan to solve flooding problem

REVERE — The solution to Roughan's Point's biggest problem? A barrier of enormous rocks to break the force of the waves, elevation of the seawall, and an additional pumping station to get water out of the section faster.

Revere

These were the remedies outlined to a gathering of Roughan's Point residents Thursday by U.S. Army Corps of Engineers project engineer J.R. Bochinno at a public hearing held at City Hall.

The hearing followed a tour of the site itself, during which various locations of the planned project were pointed out.

The city is seeking federal approval of the $11 million project to prevent the low-lying coastal section from again being devastated by flooding such as occurred in the 1978 blizzard.

Bochinno said water in some sections of the area was eight feet deep during the flooding, with much of the problem the result of waves smashing over the seawall.

Consequently, a major effort in the remedy would be directed at erecting a stone barrier to break up the force of the waves.

At the same time, the project director said, the seawall will be increased at varying heights along a 4,000-foot waterfront of the point, a second pumping station would be added to increase elimination of accumulated water in the section, and the level of roadways in the rear of the point will be increased to stop water from draining into the section.

Bochinno reported that only 84 of the 309 houses in the section are adaptable to being raised in height to prevent water from flowing readily into first floors.

Commenting on that remedy, Mrs. Ellen Haas, who heads a group of Roughan's Point residents, maintained that raising the height of the houses is not a true remedy. She called it merely making a number of "isolated islands."

Bochinno observed that the project has not yet been approved by Congress, nor has it had time to receive proper approval from the appropriate state agencies.

His comments provoked some groans when he said that, despite the speeding up of the project by two years through placing a priority upon it, it will be 1986 or 1987 before work can get under way.

Others touring the site and attending the public hearing were David Shepardson of the Metropolitan Area Planning Council, George Bricke of Coastal Zone Management, Henry Hittet of the Metropolitan District Commission, and Frank Stringi of the Revere Department of Community Planning and Development, who made local arrangements.

THE ENVIRONMENTAL MONITOR

VOLUME 18
NUMBER 7
DATE OF PUBLICATION: AUGUST 23 1982

NOTICE OF MATTERS BEFORE THE SECRETARY OF ENVIRONMENTAL AFFAIRS

This *Monitor*, the Seventh issue in Volume Eighteen of a series is intended to provide notice of all submissions received by the Executive Office of Environmental Affairs under Massachusetts General Laws, Chapter 30, Section 62 through 62H inclusive, in the period August 1 to August 15, 1982.

E-3

One of the major purposes of giving public notice is to provide an opportunity for public comments on matters before the Secretary. Such public comments are vital to an effective system of environmental review and planning. Comments should be sent directly to the Secretary with a copy to the submitting person or agency. Failure to notify the Secretary and the submitting agency may result in comments not being considered.

Copies of notification forms or impact reports noticed in this *Monitor* are required to be made available to the public by the person or agency which submitted them to this office. The name and address of the contact person for copies appears at the bottom of the page of each notification form appearing in the *Monitor*.

Submitting persons and agencies are again reminded of their obligations to submit copies of notification forms and reports to regional planning authorities and other review agencies at the same time that such reports are submitted to this office, as required by Section 10.04(1) of the Regulations Governing the Implementation of the Massachusetts Environmental Policy Act.

COMMENTS ON THE FOLLOWING NOTIFICATION FORMS ARE DUE BY:

SEPTEMBER 13 1982

Published by:
Executive Office of Environmental Affairs
100 Cambridge Street
Boston, MA 02202

Publication of this document approved by:
Alfred C. Holland, State Purchasing Agent
Publication Number — 700-2-77-129331
Estimated Cost per copy — $0.23

All comments on Environmental Notification Forms and Environmental Impact Reports must refer to the Executive Office of Environmental Affairs (EOEA) File Number. This number appears on the upper right corner of the notification form or on the list of Draft and Final reports which are available (EOEA #03001 for example). There may be other identifying numbers on a notification form but the EOEA number is the one which must be used.

NOTE: COMMENTS NOT REFERRING TO THE EOEA FILE NUMBER MAY NOT BE CONSIDERED.

All comments must be received during the comment period, which for Environmental Notification Forms ends 20 days following publication of this *Monitor*. If there is doubt as to whether a written comment will be timely received, a telephone comment may be made to this office (617) 727-5830, with a written comment to follow.

Notice is hereby given that all mail concerning the environmental impact review process including filings, comments and all associated materials MUST be addressed to:

SECRETARY
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
20th FLOOR
100 CAMBRIDGE STREET
BOSTON, MA 02202

ATTENTION: MEPA UNIT

Failure to address mail in this manner will result in delay of action on comments or no action on comment at all.

E-4

10.20: Severability.

(1) If any provision of these regulations (301 CMR 10.00 through 10.99) or the application thereof is held to be invalid by a court of competent jurisdiction, such invalidity shall not affect other provisions or the application of any part of these regulations not specifically held invalid, and to this end the provisions of these regulations thereof are declared to be severable.

(301 CMR 10.21 through 10.29: Reserved)

10.30: Appendix A - Environmental Notification Form

RECEIVED
AUG 13 1982
OFFICE OF THE SECRETARY OF ENVIRONMENTAL AFFAIRS

ENVIRONMENTAL NOTIFICATION FORM

EOEA No. 4499
TOWN: MARLBOROUGH
MEPA Contact Person: Steve KAISER
(727-5830)

I. SUMMARY

A. Project Identification
1. Project Name: Industrial Park Addition Hill - Marlborough, MA
2. Project Proponent: Cabot, Cabot & Forbes Co.
Address: 60 State Street, Boston, MA 02109

B. Project Description: (City/Town(s)) Marlborough, MA
1. Location within city/town or street address: within area bounded by Hudson St., Ash St., Fitchburg St. & Bolton St. (Route 85)
2. Est. Commencement Date: Spring 1983 Est. Completion Date: Unknown - Phased Project
Approx. Cost $ ________ Current Status of Project Design: 100 % Complete site plan
0% Building Design

C. Narrative Summary of Project
Describe project and give a description of the general project boundaries and the present use of the project area. (If necessary, use back of this page to complete summary).

Cabot, Cabot & Forbes intends to develop an industrial park on approximately 47 acres of land known as Addition Hill in Marlborough, MA. The access would be off Hudson Street approximately 1000 feet southwest of its intersection with Route 85 (Bolton Street). The road into the development would be 1950 *feet long at its completion, but would be built in phases as needed* by the pressure of users. Anywhere from one to seven lots will be developed off the access road with as many as seven buildings total. The total area of these buildings is estimated between 400,000 and 450,000 square feet.

For general project boundaries see attached plan.

The land is presently zoned industrially, is vacant (save for a house and garage on the southern portion of the property which is to be removed) and is 90% open field and 10% wooded areas.

Copies of this may be obtained from:
Name: Paul M. Dalton Firm/Agency: Cabot, Cabot & Forbes Co.
Address: 60 State Street, Boston, MA 02109 Phone No. 742-7600

1979 THIS IS AN IMPORTANT NOTICE. COMMENT PERIOD IS LIMITED.
For Information, call (617) 727-5830

10.20: Severability.

(1) If any provision of these regulations (301 CMR 10.00 through 10.99) or the application thereof is held to be invalid by a court of competent jurisdiction, such invalidity shall not affect other provisions or the application of any part of these regulations not specifically held invalid, and to this end the provisions of these regulations thereof are declared to be severable.

(301 CMR 10.21 through 10.29: Reserved)

10.30: Appendix A - Environmental Notification Form

RECEIVED
AUG 13 1982
OFFICE OF THE SECRETARY OF ENVIRONMENTAL AFFAIRS

ENVIRONMENTAL NOTIFICATION FORM

EOEA No. 4500
TOWN: Revere
MEPA Contact Person: Dave Shepardson
(727-5830)

I. SUMMARY

A. Project Identification
1. Project Name: Roughans Pt. Flood Protection Plan
2. Project Proponent: Dept. of Planning & Community Development
Address: Revere City Hall, Revere, MA 02151

B. Project Description: (City/Town(s)) Revere
1. Location within city/town or street address: Roughans Point
2. Est. Commencement Date: 1985 (spring) Est. Completion Date: 1986 (fall)
Approx. Cost $ 11,000,000.00 Current Status of Project Design: ______% Complete

C. Narrative Summary of Project
Describe project and give a description of the general project boundaries and the present use of the project area. (If necessary, use back of this page to complete summary).

The recommended Roughans Point Coastal Flood Protection is a structural solution and consist stabilizing the existing facilities along the Roughans Point shore with a rugged rock berm oping seaward 1 vertical on 3 horizontal beginning from a point 400 feet north of Elliot rcle southerly to a point 200 feet south of the intersection of Winthrop Parkway and Leverett enue (see plan #3). The plan also calls for "backwater" protection by raising the road t at the intersection of Ocean Avenue and the Revere Beach Parkway. An I wall will tie to the high ground of the Revere Beach Parkway Bridge abutment. The intersection of State ad and Endicott Avenue will also be raised and tied into high ground in a similar fashion.

Interior drainage improvements will consist of a trunkline storm drain from Sales Creek nning easterly along George Avenue to Broadsound Avenue, and then northerly to the additional mping station and extending to the existing MDC pumping station. Another storm drain will installed along Broadsound Avenue, and run easterly to the MDC pumping station.

Roughans Point is a low lying point of land of about 35 acres extending seaward just uth of Revere Beach. The entire point has now been altered by residential development and nstruction of seawalls and rock berms along the shoreline. The entire neighborhood suffers equent flooding from both coastal storms and intense rainfall events.

cont'd on page two

Copies of this may be obtained from:
Name: Frank Strinsi Firm/Agency: Dept. of Planning & Community Development
Address: Revere City Hall, Revere, MA 02151 Phone No. 284-3600 xt. 111

1979 THIS IS AN IMPORTANT NOTICE. COMMENT PERIOD IS LIMITED.
For Information, call (617) 727-5830

DAILY EVENING ITEM
LYNN, MA

JUL 30 1982

New England Newsclip

Army Corp pushes for project

Roughans Point residents asked for opinions on berm

By PHIL KEHOE
Item Staff Writer

REVERE — It's going to cost at least $11 million to build, but when completed, it'll be worth it.

The "it" is a 3,500-foot-long, 17-foot high rugged rocky berm sloping seaward from 50 to 70 feet at various

Revere

points along a line from Elliot Circle at the end of the Revere Beach Boulevard to the start of the Winthrop seawall.

The berm, if built a few years ago, would have prevented 97 percent of the $10 million-plus in damages that was inflicted on the Roughan's Point section by the Blizzard of 1978, according to the Army Corps of Engineers.

Roughans Point, whose terrain is shaped like a bowl and retains water, has been ravaged over the years and in the last 10 has been inundated by high tides, which at times have left water eight feet deep in many low-lying streets while driving hundreds from their homes.

Joseph Bocchino of the corps, speaking at an informational meeting on the project Thursday night at Our Lady of Lourdes Church Hall, urged the 35 residents in attendance to give their views so they may be included in the final survey report to be sent to federal officials later this year.

Of the $11 million needed to fund the project, about $8 million would be provided by the federal government (if approved and if Congress appropriates the funds) and $3 million by the City of Revere. The project could begin as early as 1986.

The project, whose preliminary design is part of the corps' Revere Coastal Flood Protection Study, has been endorsed by city officials as well as a Citizens' Workshop which has been meeting regularly for some months.

The corps would be responsible for the final design and overseeing the construction, which would be built by private contractors.

The berm was chosen over a breakwater because, Bocchino said, the cost of the latter would be prohibitive. The project also calls for an additional pumping station, about 400 feet from the existing station; an auxiliary power source, and associated interior drainage provisions (a subtsantially improved and enlarged storm drainage system).

Flooding from backwater would be prevented by raising the road level of two intersections, including the Revere Beach Parkway and Bennington Street intersection. Certain key stretches of roadway would also be elevated about six inches, according to Bocchino.

Bocchino said he was disappointed at the size of the turnout for the meeting, but told those on hand to spread the word to neighbors to forward their views, in writing, to him at the Corps of Engineers, 424 Trapelo Road, Waltham 02254. His telephone number is 894-2400, Extension 538.

"Your feedback is important in the eyes of Washington when officials evaluate what's been going on since the issuance of the initial survey report," he emphasized.

Bocchino said he would like to have all written comments and views from residents by September, since they will comprise an addendum to the final survey report forwarded to Washington shortly thereafter.

Bocchino said the project, whose cost would escalate depending on the rate of inflation in the next several years, would inflict "no significant adverse impact on the environment," specifically, the clam flats or the sand, because the project does not alter the present coastline.

City and corps officials will meet on Monday, Aug. 9, with the state Water Resources Commission to bring it up to date on the project. Local officials will make a case for state assistance.

Local funding will come from a bond that would first have to be approved by the state. The federal government, said Bocchino, would have to have this commitment from the city before the project could get started.

Bocchino said once federal approval for the preliminary design has been obtained, the project would come back to the New England Division of the corps for the final design. It then could be revised in such a way as to cut some of the cost or be otherwise improved.

Residents are concerned about the rapidly escalating cost of flood insurance, which one woman said has increased sixfold in the past three years for her — from an annual premium of $60 to $360.

Rita Singer, the city councilor who represents the neighborhood, said residents and officials alike should make an all-out effort to favorably influence federal officials to fund the project. "If they don't fund it, that's it. We have nothing else."

DAILY EVENING ITEM
LYNN, MA
27 JULY 1982

With Blizzard of '78 in mind

Measures to prevent flooding of Roughan's Point suggested

REVERE — A pumping station with an auxilliary power source, a rock berm (a barrier to keep waves from crashing into and over the retaining wall), and interior drainage provisions are among recommendations unuer consideration for the Roughan's Point section under a draft proposal designed to stem flooding.

Revere

The report, which puts a price tag on all proposed improvements at $11 million, also recommends raising two road intersections to prevent flooding from backwater.

The report is the topic of a workshop planned for Thursday, July 29, at Our Lady of Lourdes Hall, 1 Endicott Ave., at 7 p.m. The discussion will focus on plan selection and questions regarding the report.

A 90-day review period began in early June, and comments can be sent to the Army Corps of Engineers, 424 Trapelo Road, Waltham, before Sept. 10, with the final review document to include comments received.

The report is designed to come up with means to avoid extensive flooding of the kind that occurred in the Roughan's Point area during the blizzard of 1978.

Roughan's Point, jutting out from the Beachmont section of Revere, suffered the most damage of four Revere areas during the blizzard.

The other three areas are Point of Pines, Revere Beach, and Oak Island. Annual flood losses in Roughan's Point exceed $1 million, the report states, and if the Blizzard of 1978 occurred again, it would result in nearly $10.4 million in damages.

More than 300 structures, most of them homes, would be inundated in more than eight feet of water in a recurrence of the blizzard. The report notes that a non-structural solution would involve protection or relocation of the utilities of 46 homes and raising 51 others.

However, the plan would cost about $1.7 million and not prevent flooding.

The proposed plan would protect the more than 300 structures in the flood plain and prevent 97 percent of potential damages.

REVERE JOURNAL

FEB 10 1982

Mayor on flooding

Wants priority on study

Mayor George V. Colella has asked the Army Corps of Engineers to make their study of Revere's flooding problems a higher priority on their list of coastal projects, and to consider some suggestions he feels would improve the chances Revere will not suffer as heavily in the next major storm as it did in the Blizzard of '78.

In a letter to Col. C.E. Edgar, III, Division Engineer for the Corps, Colella stated, "I cannot stress strongly enough our support of these study efforts and our desire to see them proceed without delay. While we, as city officials, can appreciate the work and effort expended by the Corps on the City of Revere's behalf, and are cognizant of the time constraints and statutory limitations that are imposed upon the Corps procedures, we must remember that flood protection studies for Revere's coastal areas first commenced in 1970."

Colella praised the work that has been put into the protection of the people of Revere by the Corps in the past, but also noted, "It is thus difficult for those directly affected time and time again by coastal flooding to comprehend the seemingly interminable delays and endless studies."

"The shorefront property owner who has suffered through three major flooding episodes in the past ten years cares little for studies but seeks to witness real protective measures; he looks back over the past twelve years of reports and wonders when construction will take place that will secure his life and property. He knows that only the federal government has the resources necessary, but he wants to know when it will happen."

Beside his request that the Corps speed up the studies that have been made regarding Revere's shorefront, he had three suggestions to add:

1) Colella strongly supports the revision of the backwater protective alignment for the Roughan's Point Study as the highest priority, as it will increase the benefit impact on the hardest hit section of the city.

2) He concurs with increasing the Fiscal Year 1983 scheduling funds for Stage 3 of the Point of Pines study to include subsurface investigations which are necessary to identify the most cost-effective plan for the Point of Pines area.

3) He concurs that the Revere Beach area (which affects 1300 home and businesses) include Stages 2 and 3 planning for Crescent Beach, Wonderland, Oak Island, Revere Beach North and Riverside and that this all-important comprehensive effort be scheduled to start as soon as possible.

4) He supports the Stage 1 studies for the Backshore areas which affects some 1000 homes and businesses in Revere plus 1000 in Boston, Lynn, Saugus and Malden. The backshore areas comprise the Town Line Brook area, areas bordering tidal marsh, Belle Isle inlet, and areas with common plans for protection in Malden, Lynn, Boston and Saugus. The areas associated with the backshore have been subject to numerous complaints during 5 year storm flood events. He adds that he supports all efforts geared to start as soon as possible.

DAILY EVENING ITEM
LYNN, MA
4 DEC 81

30 Roughan's Point residents briefed on flood control plan

REVERE — Some 30 Roughan's Point residents seeking an end to the constant fear of flood damage by vicious coastal storms discussed alternative flood prevention measures with local officials and the Army Corps of Engineers in a workshop focusing on the latest phase of the Army study Thursday.

Revere

However, residents and officials, hearing details of two plans the Army is considering, asked for further study on a breakwater plan, previously abandoned by the engineers as too costly. Joseph Bocchino of the Army Corps agreed to ask project engineers to take another look at the breakwater alternative.

The Revere Beach Citizens Advisory Committee and area residents are working on a position paper based on the latest phase of the Army study. The paper will advise the Army on the course of action favored by the community, serving as a "guide" according to Bocchino who noted there will be more discussion at formal public hearings later this winter.

Bocchino outlined the Army's two choices for federally-backed flood protection projects, known as a structural plan and a non-structural plan.

The structural plan calls for a wave-reducing rock slope along the shore of Roughan's Point. The rock berm slope is described as a "one on three, or one foot drop on rocks measuring three feet across." The slope would cover approximately 50 feet of existing beach providing a rugged barrier to break up waves. This plan will provide access to the beach for bathers, Bocchino emphasizes. The plan also calls for improvements to drainage in the Roughan Point's area.

The cost of the structural plan is estimated at $9.6 million to be shared on a 75 per cent federal, 25 per cent non-federal arrangement, possibily a combination of city and state funds. The Army projects that this alternative will protect the area against 97 per cent of storm damage with the degree of protection described as up to 500 year storm event.

The nonstructural plan, Bocchino explained, is a combination of floodproofing; home raising, utility protection and administrative action such as flood zoning and flood insurance. This plan provides protection up to a 100 year storm event and prevents 53 percent of the storm damages. Cost of the plan, is estimated at $5.4 million shared on 80 per cent federal 20 per cent non federal arrangement.

Defining 100 year and 500 year storm events, Bocchino says, "a 100 year storm event means a storm which has the probability of happening once in 100 storms in any given year. The 500 year storm event is a storm which has the probability of happening once in 500 storms in any given year.

The Blizzard of 1978, disastrous for both Roughan's Point and other sections of the city's coastline, was a 100 year storm event, says Bocchino, noting a 500 year storm event would probably pack five times as much power and devastation as the 1978 blizzard.

DAILY EVENING ITEM
LYNN, MA
30 NOV 81

Meeting Thursday

Anti-flood projects planned for Revere

REVERE — Residents of the flood-prone Roughan's Point area of Beachmont will look at proposed flood prevention projects which could cost from $8.5 million to $19 million in a meeting with representatives of the Army Corps of Engineers Thursday night.

Revere

The meeting, for public comment and testimony on the latest phase of the Army Engineers ongoing coastal protection study, will get under way at 7 at Our Lady of Lourdes Church Hall.

Representatives of the Army Corps of Engineers in Waltham will discussin detail four preliminary plans for flood prevention outlined in phase two of the Army's Coastal Flood Protection Study, released in September of 1981.

Each plan proposes an alternative combination of flood prevention remedies such as breakwater construction, revetments, beach restoration, rip rap walls and various types of floodshields.

The meeting was organized by the Revere Beach Citizens Advisory Committee and the city's Community Development Office.

Copies of phase two of the Army study have been at Revere Public Library for review and community development officials urge residents to attend the meeting and give testimony as to their home's individual flooding problems andget involved in the selection of a rememdial plan.

The Army has been studying beachfront flooding problems in depth since Mayor George V. Colella pushed for federal help in Washington, D.C. shortly after the blizzard of 1978 devastated coastal sections of the city.

In addition to studying the Roughan's Point section, the Army Corps' studies are addressing flooding in Oak Island, Point of Pines and the North Shore Road area.

The preliminary report, issued last year, suggested it will take upwards of $32 million in remedial work to protect all four areas against flooding

However, officials note it will take more years of study and Congressional approval for funding before beach area residents can expect to see remedial projects begin.

Roughan's Point alone could stand from $8.5 to $19 million worth of work, depending on which alternative is chosen.

The Army Corps has run several public workshops on area flooding problems, and last spring, input by Roughan's Points residents was documented after families filled out questionaires detailing their homes' individual flooding problems.

DAILY EVENING ITEM
LYNN, MA
D. 32,440

MAY 27 1981

New England Newsclip

Roughan's Point

Flood protection concerns of Roughan's Point residents will be aired at a workshop conducted by the Army Corps of Engineers in conjunction with its coastal flood protection study Wednesday, May 27, at 7 p.m. at Our Lady of Lourdes Church.

Residents who have completed and returned questionnaires concerning their own home flooding experiences are urged to attend the workshop. Residents who have not returned the questionnaires are urged to send them to Joseph Bocchino, project manager, New England Division, Corps of Army Engineers, 424 Trapelo Road, Waltham.

DAILY EVENING ITEM
LYNN, MA
D. 32,440

APR 10 1981

New England Newsclip

Army needs help in determining work at Roughan's Point

Revere

REVERE — The Army Corps of Engineers has a message for owners of ~~flood-plagued homes on~~ Roughan's Point.

"The Army needs you to become actively involved if we are going to make a case for federal flood protection program funding," is the message from Joseph Bocchino, project manager of the Revere Coastal Flood Protection Study.

Bocchino is appealing to Roughan's Point residents to return questionnaires as soon as possible to the Army Corps of Engineers and "get involved" in an upcoming workshop and public hearing to air solutions to flooding in the beach area.

Earlier this month more than 500 four-page questionnaires including self-addressed return envelopes, went out to Roughan's Point residents.

"These questionnaires basically ask each family's experience with flooding so we can gather the pertinent information to formulate plans for remedial work," said Bocchino.

The Army has been studying beachfront flooding problems in depth since Mayor George V. Colella pushed for federal help in a Washington, D.C., trip after the Blizzard of 1978.

The Army Corps' preliminary report, issued last year, suggested it will take about $32 million in remedial work to cure flooding in four major areas of the beach.

Roughan's Point, Oak Island, the Point of Pines and North Shore Road areas were addressed in the study which suggested a number of flood protection alternatives ranging from construction of rip rap walls, tidal gates, construction of a pumping station to raising a section of North Shore Road.

Bocchino said public input is the best indicator to the federal government that there is a need for federal dollars to implement remedial work.

On Wednesday, the project manager will brief the City Council on the progress of the Coastal Flood Protection Study which will be released later this spring.

The Army Corps of Engineers is also setting up a workshop and a publichearing for beach area residents in May. The dates, times and locations of both public sessions will be announced soon, Bocchino said.

Wednesday's council briefing will touch upon various proposals, including a $7 million project to replace sand on Revere and Crescent Beaches; construction of a stone berm on the ocean side of the Roughan's Point seawall; and a plan to raise existing seawalls and replace rocks and sand dunes in the Point of Pines.